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# THE
# THIRTEENTH
# ANNUAL REPORT

—OF THE—

# MARYLAND
# Agricultural - Experiment - Station,

—AT THE—

## AGRICULTURAL COLLEGE,

COLLEGE PARK.

PRINCE GEORGE'S CO. MARYLAND.

1899-1900.

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# THE
# Maryland Agricultural Experiment Station.

## CORPORATION.
## THE BOARD OF TRUSTEES OF THE MARYLAND AGRICULTURAL COLLEGE.

### Agricultural (Station) Committee of the Board of Trustees

| | |
|---|---|
| Governor John Walter Smith, (Ex-Officio) | Annapolis. |
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### Station Officers and Staff.

| | |
|---|---|
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| James S. Robinson | *Horticulturist.* |
| Willis G. Johnson, A. M. | *Entomologist.* |
| Milton Whitney | *Soil Physicist.* |
| Samuel S. Buckley, D. V. S. | *Veterinarian.* |
| Charles O. Townsend, M. S. Ph. D. | *Plant Pathologist.* |
| W. T. L. Taliaferro A. M. | *Agriculturist.* |
| E. O. Garner | *Farm Superintendent.* |
| Charles F. Doane, M. S. Ag. | *Assistant Dairyman.* |
| Guy L. Stewart, B. S. | *Assistant Pathologist.* |
| Harris P. Gould, M. S Ag. | *Assistant Entomologist.* |
| T. M. Price, M. S. | *Assistant Chemist.* |
| F. P. Vietch, M. S. | *Assistant on Soil Work.* |
| Joseph R. Owens, M. D. | *Treasurer.* |
| Donald Eversfield, A. B. | *Clerk.* |

**The Station is Located on the B. & O. R. R. and City & Suburban Electric Car Line, 8 miles north of Washington, D. C.**

Visitors will be welcomed at all times, and will be given every opportunity to inspect the work of the Station in all of its departments.

The Bulletins and reports of the Station, will be mailed regularly, free of charge to all residents of the State who request it.

ADDRESS:

AGRICULTURAL EXPERIMENT STATION,
College Park, Maryland.

## LETTER OF TRANSMITTAL.

*To His Excellency, John Walter Smith,*
*Governor, and President of the Board of Trustees.*
*Annapolis, Maryland.*

Sɪʀ.—In accordance with the provisions of Section No. 3, of the Act of Congress, approved March 2d, 1887, "To Establish Agricultural Experiment Stations, etc." I have the honor to transmit the Thirteenth Annual Report of the Maryland Agricultural Experiment Station for the fiscal year ending June 30th, 1900.

Very respectfully yours.
H. J. PATTERSON,
Director of the Expt. Station.

Transmitted September, 1900.

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THE MARYLAND

AGRICULTURAL EXPERIMENT STATION.

VOLUME 13. 1899-1900.

## —THE—

# THIRTEENTH ANNUAL REPORT.

FOR THE FISCAL YEAR, JULY 1, 1899 TO JUNE 30, 1900.

The report transmitted herewith is made in accordance with the plan adopted by the Agriculture Committee of the Board of Trustees, and described and followed in the twelfth annual report.

The work of the Station has been continued in the lines already outlined, and broadened whenever the means at hand would permit and the opportunity was presented.

The aim in all the station work is to build on a good solid foundation, and to have the Station workers put forth their best efforts in solving problems that will have a value for future, as well as immediate, application, and this work, in the main, is going smoothly and satisfactorily. As time passes the Station facilities for work become more complete, and, thus far, each year requires less time and money to be expended upon preparation, and more for labor and current expenses of experimentation. But the time has come, with our fixed income, that it is impossible to answer the numerous demands for experiments in the various fields. Not only is it impossible to increase the variety of our work, but also to materially add to the quantity. In fact, under present conditions, it is questionable if it would not be better policy to concentrate our efforts upon a few of our most important interests, rather than cover the great variety of this State: and depend upon the work of other Stations, which is of general application. The difficulties of having too many irons in the fire at one time has been forcibly felt in our soil investigations, which were started ten years ago on a limited income with no means for expansion. The work of the Maryland Station on soils led to the establishment of the Division of Soils of the U. S. Department of Agriculture, and all their present work had its inception, in all essential details, in the investigation conducted here. The alkali work of the far west, which has had such an important practical bearing, is merely an application of the electrical methods which were originated under the auspices of the Maryland Experiment Station. The Soil Survey, with the methods of classifying lands, and the detailed mapping of soils, was first worked out and first put in practice by this Station. These several lines of work have been widely applied and generally adopted, for which we are grateful; but we regret that, to a great extent, it has been at the expense of our State, as our financial condition did not permit us to hold the man of experience who had the ability to work out the difficult problems of our State so as to place the results in such a tangible shape as to be of practicable application. There are many times when just such conditions will confront us when running at the maximum of our capacity, and the aim in such work as ours should be to always have some reserve force in the way of a contingent or emergency fund.

In the early days of the Station variety tests were conducted on an extensive scale, with field crops, fruits and vegetables. In the future these will be conducted only to a limited extend, and, in their place, considerable work has been instituted in plant selection and breeding, with an idea of acquiring such strains or varieties as will be particularly adapted to our particular climate and soils.

The general condition of the Station has been considerably improved during the past financial year, and much has been added to our facilities for work in particular lines.

One year ago the portion of the farm which had been under the supervision of the President of the College and run as the College farm, was added to the Experiment Station farm. This brought to the Station considerable more in the way of general farm work, but also at the same time offered an opportunity to produce much in the way of feeds, &c., that the Station previously had to purchase in the open market. Again, with the College farm, came a market for a considerable part of our dairy, vegetable and fruit products, so that sales of farm produce has more than balanced the increased expense. The policy adopted for the whole farm is to make everything contribute, either directly or indirectly, toward the experiments in hand. With this policy vigorously enforced, the present arrangements of the farm ought to contribute each year more and more to our facilities for acquiring information, and to such an extent will be a means of aiding the farmers of the State.

*Visitors and Correspondence*—These two methods of intercourse with those who are interested in the work of the Station are encouraged as much as possible, and both are increasing yearly. No opportunity is lost to make it known that visitors, singly or in parties, and without previous notice, are always welcome, and that every effort will be made to make such visits pleasant and instructive. Those who cannot come are encouraged to write, suggesting and enquiring; and the Station officials give such letters every possible attention. The correspondence of the Station, and those requesting to be placed on our regular mailing list are constantly increasing in number.

This is encouraging, yet it is to be regretted that more of our farmers do not avail themselves of the opportunity for information through our bulletins; which may be had for the asking. At the present time our bulletins are sent to about 8,000 farmers, but we would be glad to have a copy go to each of the 40,000 farmers of the State.

*Publications*—During the past year there has been issued by the Station the following publications:

The Twelfth Annual Report, covering the work of the fiscal year 1898-1899.

Bulletin 63.—Three years Experiments in Pig Feeding.

Bulletin 64.—Study of the Causes of Mottled Butter.

Bulletin 65.—Spraying for Insects and Fungi.

Bulletin 66.—The Occurrence and Composition of the Lime Deposits in Maryland, with an account of the results of all the tests of lime at the Station to date.

Bulletin 67.—The Cultivation and Handling of Maryland Tobacco, with Illustrations showing the root system at different stages of growth.

*Station Staff*—The Station Staff, in the main, continued the same as the previous year. The changes consisted in the appointment of Thos. Malcolm Price, a graduate of the Maryland Agriculture College, Class of 1899, as Assistant Chemist. Harris P. Gould, a graduate of the University of Maine and post-graduate of Connell University, was appointed Assistant Entomologist to succeed E. Dwight Sanderson who resigned to accept the chair of Entomologist at Delaware Agricultural College. F. P. Vietch, a graduate of the Maryland Agricultural College, Class of 1891, who has been assistant in the State fertilizer control work, was appointed to fill the vacancy as assistant in the Soil Physics investigations. W. T. L. Taliaferro, professor of Agriculture in the College, was assigned to take up work at the Experiment Station in the capacity of Agriculturist. The designation of the position occupied by E. O. Garner was changed from Assistant Agriculturist to Superintendent of Farm. Donald Eversfield, Class of 1896, Maryland Agricultural College, was appointed Clerk, vice Robert E. Browning, resigned.

*Weather Report and Financial Statement.*—The following tables on pages and give, respectively, the meteorological summary for 1899, and the report of the Treasurer, showing the Station receipts and expenditures for the fiscal year ending June 30, 1900.

It will be noted that the Treasurer's report shows a very considerable increase in the amount spent for machinery and implements. This increase was incurred chiefly through the necessity of purchasing a new boiler for heating the Station buildings, and making needed changes in the heating and power plant.

The increase in the amount spent for labor and fertilizers over the previous year was caused by the adding of the College farm to the Experiment Station Farm ; but it will be noted that the increased expenditures were more than covered by the increased sales of farm produce. Again, the produce of the farm enabled the feeding of considerably more stock than was carried previously, without increasing the bill for feed-stuffs.

## METEOROLOGICAL SUMMARY FOR 1899.

### TEMPERATURES IN DEGREES.

(FAHRENHEIT.)

| MONTH | PRECIPITATION | Temperatures—Mean. | | | | Extreme Maximum. | Extreme Minimum. |
|---|---|---|---|---|---|---|---|
| | | Daily Means. | Maximum. | Minimum. | Daily Range. | Record & date. | Record & date. |
| January | 3.32 | 35.0 | 44.0 | 26.6 | 17.3 | 48—14th | 11—28th |
| February | 3.57 | 33.2 | 34.8 | 21.2 | 14 0 | 59—20th | 4— 9th |
| March | 8.00 | 42.1 | 50.0 | 30.0 | 14.4 | 71—12th | 22— 9th |
| April | 5.90 | 52.2 | 66.7 | 41.8 | 12.4 | 84—30th | 27— 4th |
| May | 1.71 | 63.9 | 75.9 | 41.9 | 26.3 | 92—29th | 39—26th |
| June | 4.22 | 74 0 | 75.6 | 62 9 | 22.1 | 98-- 7th | 51—19th |
| July | 2.50 | 76.2 | 83 0 | 66.2 | 20.3 | 95—22d | 56—11th |
| August | 5.51 | 72.5 | 83.0 | 62.0 | 31.0 | 96—27th | 52—22d |
| September | 5.45 | 63.7 | 75.7 | 52.7 | 24.8 | 87—1st, 29th | 36—28th |
| October | 1.35 | 56.9 | 68.6 | 45.6 | 31.0 | 79—13th,28th | 28—1st |
| November | 2.95 | 44.1 | 55.6 | 32.6 | 39 0 | 70—11th | 20—13th |
| December | 1.62 | 34.3 | 45.5 | 23.5 | 34.0 | 64—12th | 5—31st |
| Yearly | 45.8 | 54.0 | 63.2 | 41.4 | 23.9 | 98—June | 5—December |

## FINANCIAL REPORT FOR 1899-1900.

Jos. R. Owens, Treasurer, in account with the Maryland Agricultural Experiment Station.

| 1899. | SOURCE OF REVENUE. | |
|---|---|---|
| July 1, | To unexpended balance | $ 5.69 |
| " | To U. S. Appropriation | 15000.00 |
| " | To Sale of Farm Produce | 2830.94 |
| | | $17836.63 |

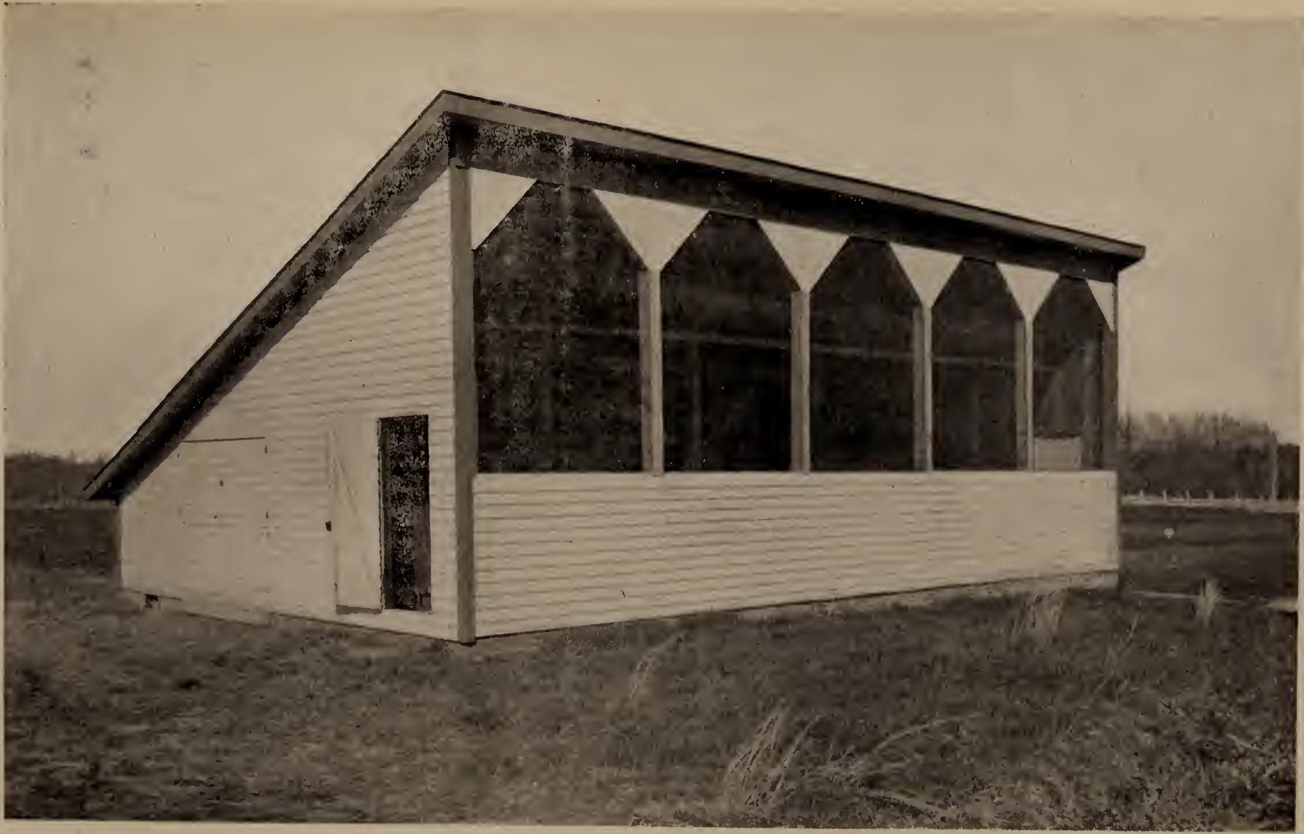
| 1900 | | NATURE OF EXPENDITURE. | |
|---|---|---|---|
| June 30, | By | Salaries | 7375.92 |
| " | " | Labor | 3688.06 |
| " | " | Publications | 851.18 |
| " | " | Postage and stationery | 134.17 |
| " | " | Freight and Express | 235.66 |
| " | " | Heat, Light and Water | 355.58 |
| " | " | Tools, Implements and Machinery | 1459.62 |
| " | " | Seeds, Plants and Sundry Supplies | 761.04 |
| " | " | Chemical Supplies | 152.80 |
| " | " | Fertilizers | 439.83 |
| " | " | Feeding Stuffs | 1073.33 |
| " | " | Library | 199.93 |
| " | " | Furniture and Fixtures | 11.00 |
| " | " | Scientific Apparatus | 138.70 |
| " | " | Live Stock | 202.50 |
| " | " | Traveling Expenses | 207.41 |
| " | " | Contingent Expenses | 158.00 |
| " | " | Buildings and Repairs | 293.18 |
| " | " | Unexpended Balance | 98.72 |
| | | | $17836.63 |

I, the undersigned duly appointed Auditor for the corporation, do hereby certify that I have examined the books and accounts of The Maryland Agricultural Experiment Station for the fiscal year ended June 30, 1900; that I have found the same well kept and classified as above set forth, and that the receipts for the year are there shown to have been $17,836.63, and the corresponding disbursements to have been $17,737.91.

Vouchers for the expenditure of all of this have been examined by me and found correct. The work has been carefully and accurately performed throughout, and an unexpended balance of money remains, in the full sum of $98.72, which is to be accounted for by the Treasurer in the fiscal year commencing July 1, 1900.

WM. H. MARRIOTT,

Auditor and Expert Accountant.



Hog House (Outside front view)

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 63. DECEMBER 1899.

# EXPERIMENTS IN FEEDING PIGS FOR THE PRODUCTION OF PORK.

By H. J. Patterson, B. S. Director and Chemist.

## GENERAL CONSIDERATIONS.

According to the Eleventh Census of the United States there were 312,000 hogs produced annually in Maryland, of which 186,000 were consumed in the State. These represented a value of about 1,500,000 dollars. The amount produced by the various counties is represented by the following figures:

| | |
|---|---|
| Allegany | 3,576 |
| Anne Arundel | 8,817 |
| Baltimore | 22,771 |
| Baltimore City | 139 |
| Calvert | 5,861 |
| Caroline | 6,668 |
| Carroll | 28,345 |
| Cecil | 12,758 |
| Charles | 10,524 |
| Dorchester | 12,145 |
| Frederick | 41,002 |
| Garrett | 6,445 |
| Harford | 16,466 |
| Howard | 10,742 |
| Kent | 11,350 |
| Montgomery | 17,836 |
| Prince George | 10,385 |
| Queen Anne | 12,152 |
| St. Mary's | 12,540 |
| Somerset | 6,425 |
| Talbot | 11,011 |
| Washington | 26,124 |
| Wicomico | 7,277 |
| Worcester | 10,661 |

These figures show that hogs are an important factor in the annual proceeds of the Maryland farm, but, aside from the volume of wealth which they represent, they have such a close relation to the every day sustenance of the farmer, his family and his laborers, as to probably make them occupy a place next to bread in the dietary. These factors make the production of pork of special interest and make it desirable to know how it may be produced not only economically, but of the very best quality. Again, on most farms and indeed with many families living in small places there are considerable waste products that will go far toward feeding the pigs, so that it is only necessary to make a proper study of supplementary foods in order to make pork contribute materially to the annual income.

Discussions at farmers clubs, institutes, and general inquiry has shown that there is very little definite knowledge as to the cost of production of pork, yet there is a prevalent idea in the minds of those who have thought seriously on the subject that the cost of production is very often more than the market value, and the statement is not infrequently made that most farmers would save money by purchasing the family supplies in the market. Yet here and there a person is found who considers pork one of the profitable products of the farm, and sometimes contends that it can be produced for three cents per pound even though others say eight to twenty-five cents per pound. The quality of the pork is also a point upon which there is considerable variance of opinion, and justly so. This latter point is most always attributed to the methods of curing and cooking, but for all of the reasons the food and feeding of the hog will also have to be taken into account. These facts, together with a desire to utilize waste products, were the reasons which caused the inauguration of the experiments in pork production at this place. The experiments which shall be recorded in this Bulletin are only a few of many which are planned, but give the results so far as determined in three years work. The tests undertaken were such as seemed to be of interest to our people and which the facilities at command made it possible to undertake. Some of the results obtained are fairly conclusive while others will need to be confirmed and supplemented; while still others only give data suggesting future lines of work.

The main aim in all the work has been to test foods within easy reach or methods which could be easily adopted with slight modifications. Again in some of the work it has been the aim to point out means by which the rations commonly used could be modified so as to conform to nature and allow the pig to be fed as nearly as possible as they feed themselves when allowed to run, or in the wild state and not to subject them wholly to artificial methods of feeding as well as living.

## HOG HOUSE.

In connection with reporting the results of the feeding experiments which will be found on the following pages it seems to be desirable for many reasons to give some pictures and a description of the hog house which is in use at this place.

Most of the plans for hog houses recorded in literature on this subject refer to those made further north or west where the climate is more severe than in this latitude. This is due no doubt to two causes; first that the hog house of the south has seldom materialized, at least to such a point as to be worthy of being dignified as a house or much less described, for it generally consists of a brushy marsh for summer and a square made of a few old fence rails with some pine brush or corn fodder thrown over the top for winter.

The hog house of the north may suit that latitude but no doubt could be improved upon for that section, and it certainly has many objections for the south; generally the greatest objection being the cost. There is one point that is commonly lost sight of in hog growing and that is that he is an animal to which sun shine is just as essential as it is to the corn plant. Neither corn nor pork can be successfully produced without plenty of sunshine. In the north this sunshine in winter will have to be brought into the pens through glass. In this latitude and further south under normal conditions it is only necessary to face the pen to the south; allow the sun's rays to reach to the back of the pen on the beds and give good shelter and protect from the north and west winds.

The following end elevation and floor plans, together with the pictures, give almost a complete idea of the pen in use here which has met with very general favor. It may, however, be well to enumerate a few of the special points in construction.

1st.—It is faced to the south so as to permit the rays of the sun to shine upon the beds of the pigs at the extreme rear end of the pen in the winter season and also to give shade in that portion in summer.

2nd.—The lattice construction between the pens at the ends and rear admit of a free circulation of air in warm weather.

3rd.—The location of the manure pit in the centre and below the level of the sleeping and feeding floors with all drainage toward it, aids materially in maintaining a proper sanitary condition.

4th.—The ease and facility with which the manure can be removed.

5th.—The swinging gates close the pigs into their beds while the manure is being loaded.

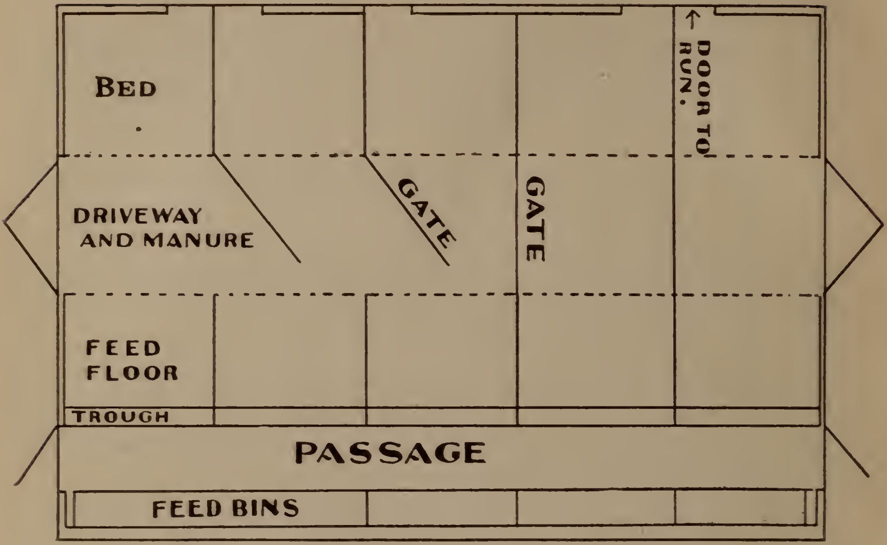
6th.—The swinging fronts to the pens permit the food to be easily placed in the trough and evenly distributed so that the pigs have an equal chance at feeding time.

7th.—The manure pit is concreted which enables the saving of all liquid excrements which with the pig amounts to 51 per cent of the total manure value.

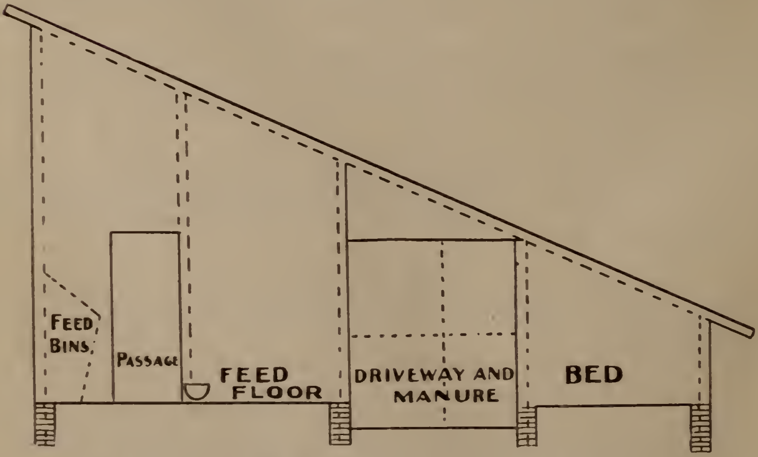
8th.—Ease of changing pigs from pen to pen.

9th.—Feed bins are placed in front of each pen which facilitates feeding and enables keeping different feeds for each pen if desired.

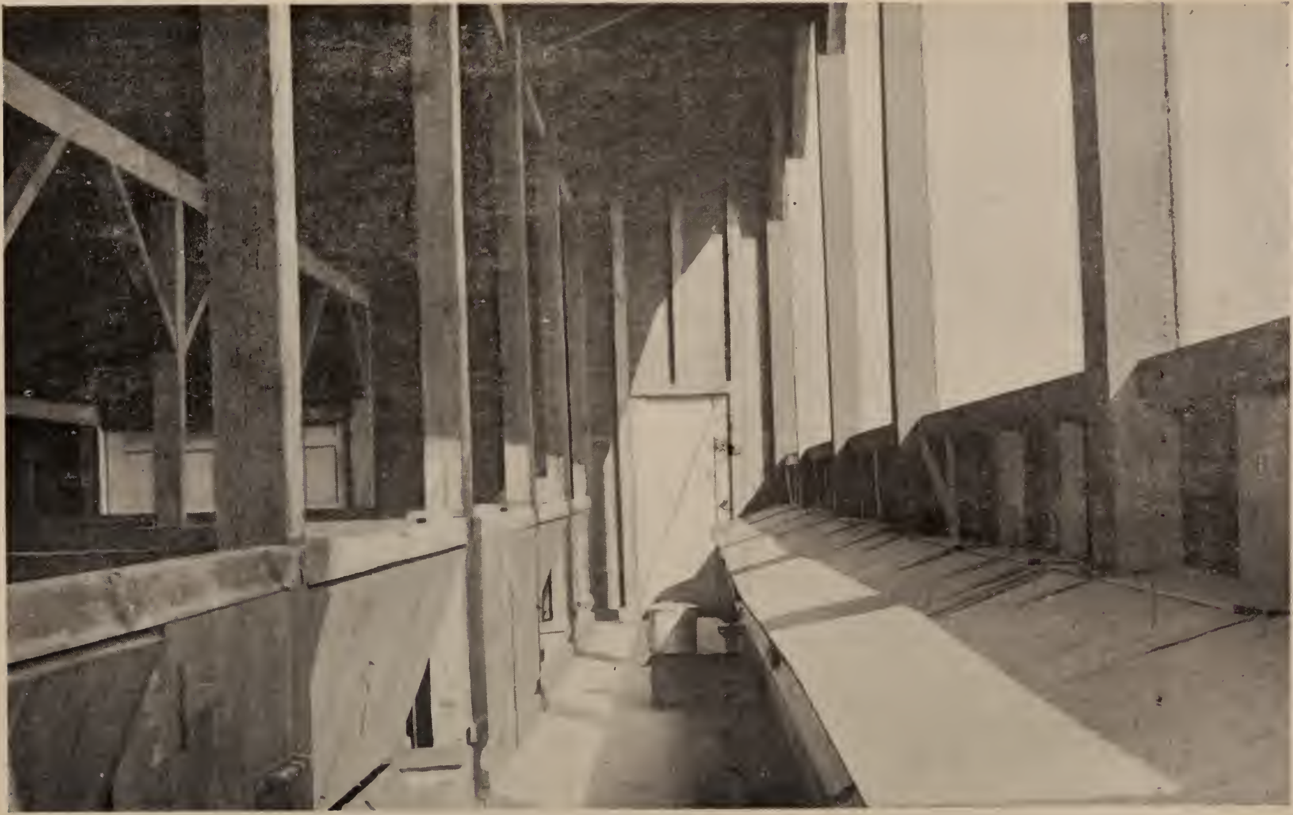
10th.—The general plan can be used and the dimensions and materials modified so as to meet the demand of circumstances.



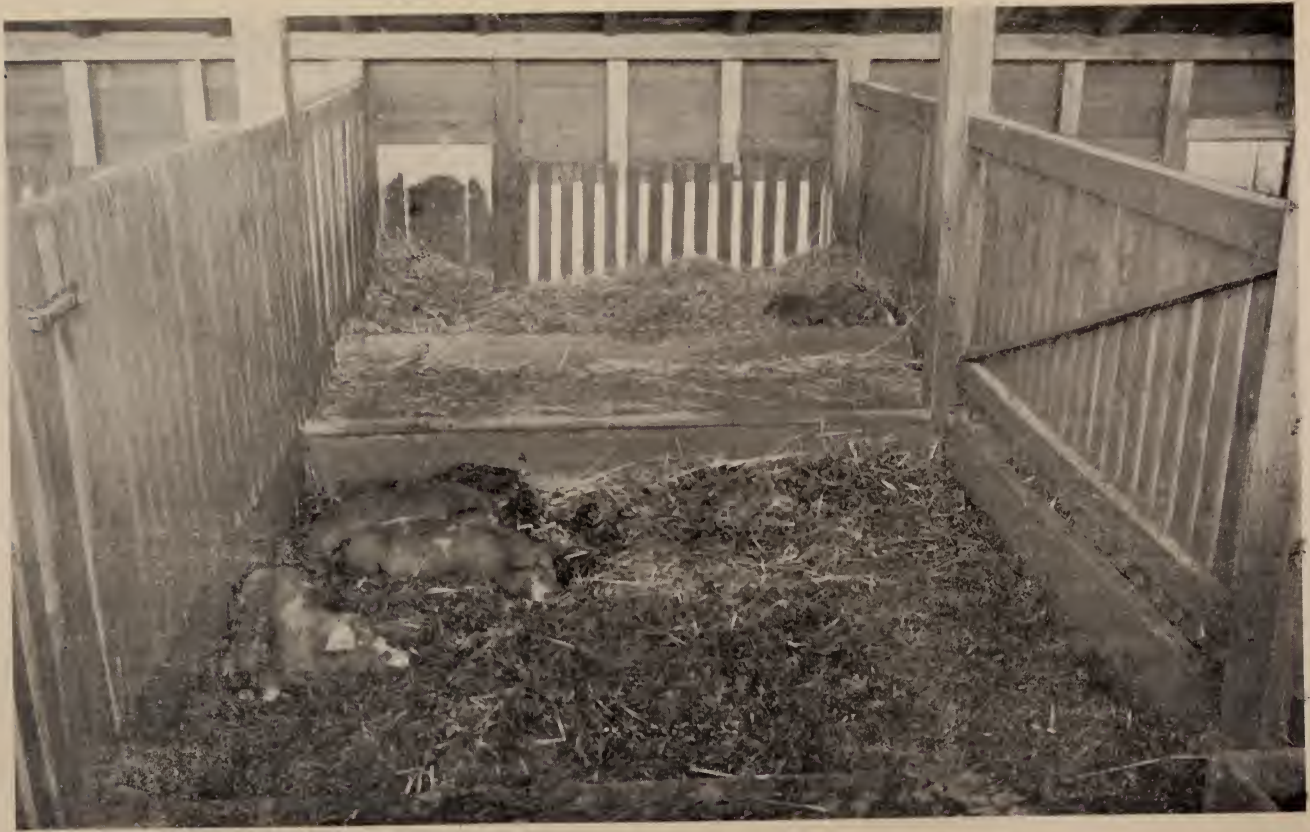
General floor plan of hog house. Scale, 1-10 inch to 1 foot.



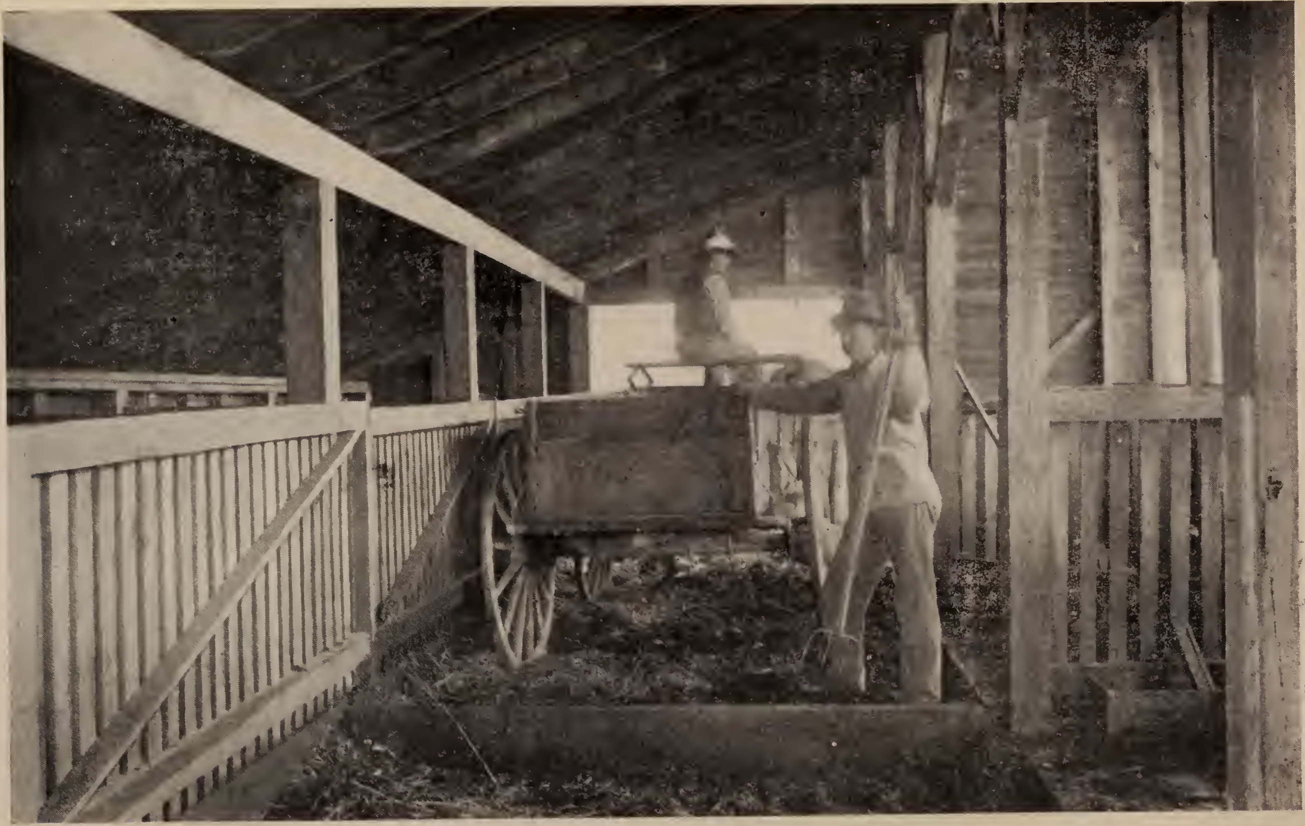
End elevation of hog house. Scale, 1-8 inch to 1 foot.



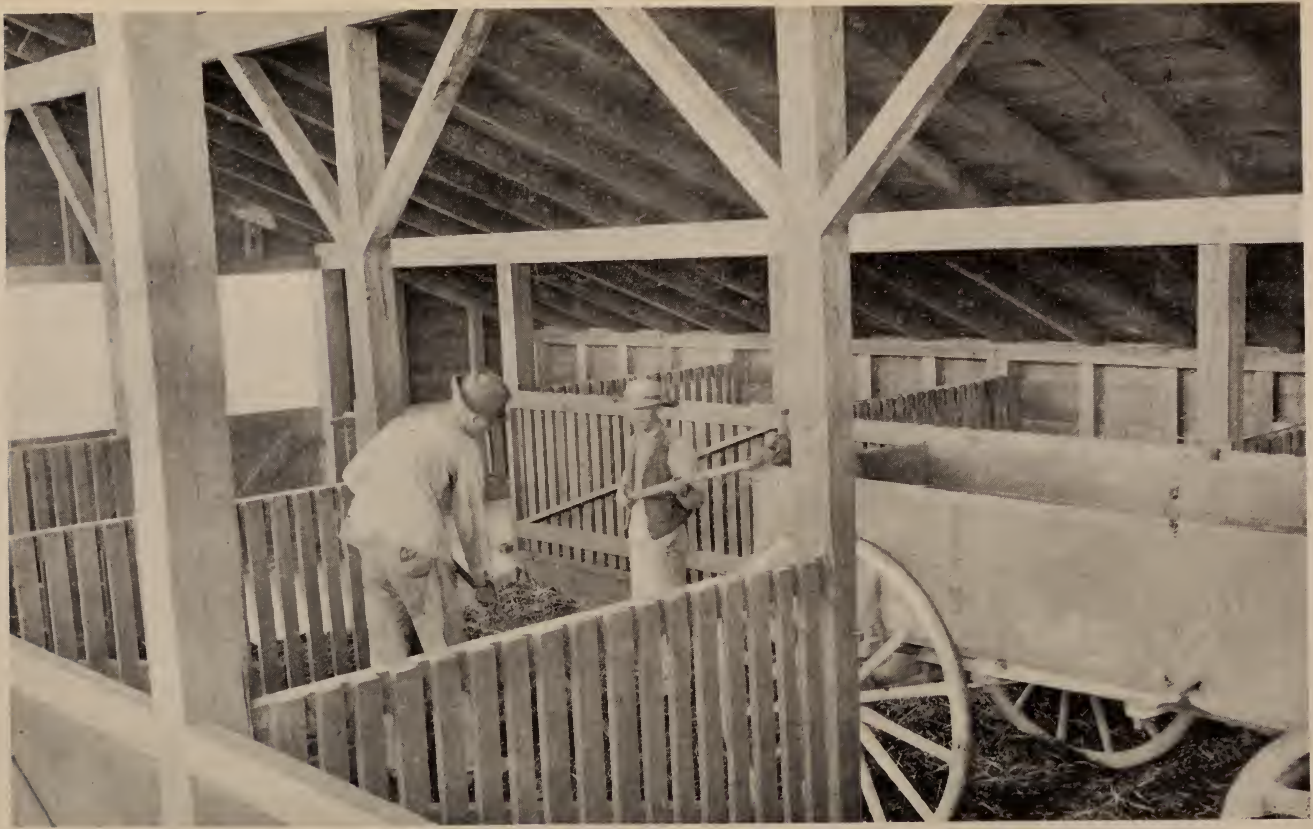
Hog House—Interior view showing feed bins and feeding alley.



Hog House—Interior view showing bed in rear of pen.



Hog House—Interior view showing method of driving into the pen for the manure.



Hog House—Interior view showing wagon in place for loading manure.

# PIG FEEDING EXPERIMENT NO. 1.

## A COMPARISON OF THE USE OF SKIM MILK AND GREEN CLOVER AS ADDITIONS TO A RATION FOR PIGS.

The object in this and in all subsequent pig feeding experiments is to determine the most economical means of feeding hogs, considering both the feeds and ages of the pigs, or in other words the aim is to arrive at the most profitable means of producing pork with the feeds and conditions at the command of the Maryland farmers.

It is very common to hear farmers state that their pork costs more than they get for it and no doubt, if strict account were kept, a large percentage of the pork produced by Maryland farmers costs more than it will bring on the market. This is due probably to two causes; the method of feeding and the character and age of the pigs fed.

The pigs used in this experiment were Jersey Red and Berkshire grade crosses and were purchased from W. S. Powell, Esq., of Annapolis Junction, Md. The pigs were at first purchased only with a view of utilizing waste products from the creamery but after they had been here for some time it was decided to use them for making some tests as well.

The pigs were from two litters and were so divided as to give three pigs from each litter in each lot. A crude pen was constructed from such rough lumber as was at hand. This pen was not well adapted to experimental purposes as it gave poor facilities for weighing the pigs frequently and did not afford proper protection from the sun of summer and the cold of winter. An attempt was made to follow the individual pigs by placing in their ears "Dana Ear Tags," but these were soon lost from the most of the pigs and each lot had to be considered as a unit.

The pigs were purchased when they were about eight weeks old and fed all the same until April 27th, when they were put on the rations under test. The preliminary ration consisted mostly of milk and some gluten meal, and wheat bran.

RATIONS USED:—The idea at the time of planning the experiment, was to balance the ration of one lot with separator skim milk and to furnish the other lot with an equivalent amount of protein to be gotten in green clover or other green leguminous crops, according to the season.

To do this would require for each ten pounds of milk fed, approximately 8 ponnds of either Red Clover, Crimson Clover, or Alfalfa and 15 pounds of Cow Pea vines. In practice it was found impossible to get the pigs to eat anything like the above proportions, so it was decided that the best thing to do would be to feed the skim milk in about such quantities as would give a balanced ration for the different periods, and to feed the green clover in such quantities as the pigs would consume.

Each lot received the same grain mixture, and the milk or clover, respectively, in addition. The quantity of grain given was guaged according to the demands of the appetites of the pigs.

## GRAIN MIXTURE USED.

The following is the grain mixture used, together with the cost of the same at the ruling price of the market for feeds delivered at this point at that time.

### TABLE I.

*Grain Ration and Cost of Same.*

| | | | |
|---|---|---|---|
| Corn and Cob meal | 800 lbs. | at 50 cts. per hundred, | $4.00 |
| Linseed meal | 100 " | 88 " " | 88 |
| Gluten meal | 100 " | 67 " " | 67 |
| Total, | 1000 | | $5.55 |

The amount of digestible food constituents is shown by the following figures:

### TABLE II.

*Grain Ration and Digestible Matter Furnished by the Same.*

| Kind of Feed | Quantity in pounds | DIGESTIBLE | | | |
|---|---|---|---|---|---|
| | | Protein | N. free extract | Fat | Nutritive ratio |
| Corn and Cob Meal, | 800 | 35.2 | 480.0 | 23.2 | 1:15.1 |
| Linseed Meal. | 100 | 31.8 | 32.3 | 7.1 | 1: 1.5 |
| Gluten meal, | 100 | 28.7 | 32.2 | 15.5 | 1: 2.3 |
| | 1000 | 95.7 | 544.5 | 45.8* | 1:6.76 |
| | | | 647.6 | | |

*In the calculation 1 pound of fat is rated as equivalent to 2¼ lbs. of starch or nitrogen free extract.

### TABLE III

*Composition of Feeds Used.*

| | Water per cent | Ash per cent | Protein per cent | Crude fibre per cent | N. free exact per cent | Fat per cent |
|---|---|---|---|---|---|---|
| Corn and Cob meal, | 15.10 | 1.50 | 8.50 | 6.60 | 64.80 | 3.50 |
| Linseed meal, | 10.00 | 4.38 | 37.36 | 8.98 | 31.70 | 7.60 |
| Gluten meal, | 11.41 | 1.68 | 34.16 | 1.76 | 35.19 | 15.80 |
| Green Clover, | 70.80 | 2.10 | 4.40 | 8.10 | 13.50 | 1.10 |
| Separator Skim milk | 90.60 | 0.70 | 3.20 | —— | 5.40 | 0.10 |

The quantity of food consumed by the pigs in the two lots, together with the digestible matter contained therein is shown in tables IV and V.

### TABLE IV.

*Digestible Nutrients Consumed by Lot A.*

| | Quantity pounds | DIGESTIBLE<br>Protein pounds | <br>Carbohydrates pounds |
|---|---|---|---|
| Grain Ration, | 4695 | 449.3 | 3040.5 |
| Skim milk (Separator) | 18312 | 549.4 | 1007.2 |
| | | 998.7 | 4047.7 |

Nutritive Ratio of Food Consumed 1:4.

### TABLE V.

*Digestible Nutrients Consumed by Lot B.*

| | Quantity pounds | DIGESTIBLE<br>Protein pounds | <br>Carbohydrates pounds |
|---|---|---|---|
| Grain Ration, | 4242 | 406.0 | 2747.1 |
| Clover (Green), | 864 | 25.9 | 128.7 |
| | | 431.9 | 2875.8 |

Nutritive Ratio of Food Consumed 1:6.6.

The weights of the pigs, gains &c. are shown by the following figures:

### TABLE VI.

*Weights and Gains of Pigs.* (*Six pigs in each Lot.*)

| | Lot A | Lot B |
|---|---|---|
| Weight April 27, 1896, when pigs were started upon experiment | 278 lbs. | 283 lbs. |
| Weight October 8, 1896, end of experiment | 1523 | 879 |
| Total gain in 165 days, | 1245 | 596 |
| Gain per day, | 7.55 | 3.61 |
| Gain per pig, | 207.5 | 99.30 |
| Gain per day per pig, | 1.26 | .60 |
| Average weight at beginning of experiment, | 46.3 | 47.2 |
| Average weight at end of experiment, | 253.8 | 146.5 |

| | |
|---|---|
| Range of weight in Lot A at beginning of experiment, | 42 to 59 lbs. |
| Range of weight in Lot A end of experiment, | 209 to 293 lbs. |
| Range of weight in Lot B at beginning of experiment, | 36 to 58 lbs. |
| Range of weight in Lot B end of experiment, | 112 to 190 lbs. |

## DISCUSSION OF RESULTS OF FEEDING EXPERIMENT NO. 1.

In Lot B, there was 3307.7 lbs. digestible nutrients consumed to make 596 lbs of pork or 5.55 lbs. digestible nutrients to each 1 lb. of pork. The clover furnished 128.7 lbs. of nutrients or the equivalent of 28 lbs. of pork, which deducted from 596 lbs. allows 568 lbs. as produced by 4242 lbs. of the grain ration or 7.47 lbs. of grain to one lb. of pork, which at a cost of

$11.10 per ton for the grain ration made the pork produced by the grain cost $4.15 per Cwt., and the portion attributed to the clover cost $3.09 per Cwt. when green clover is worth $2.00 per ton.

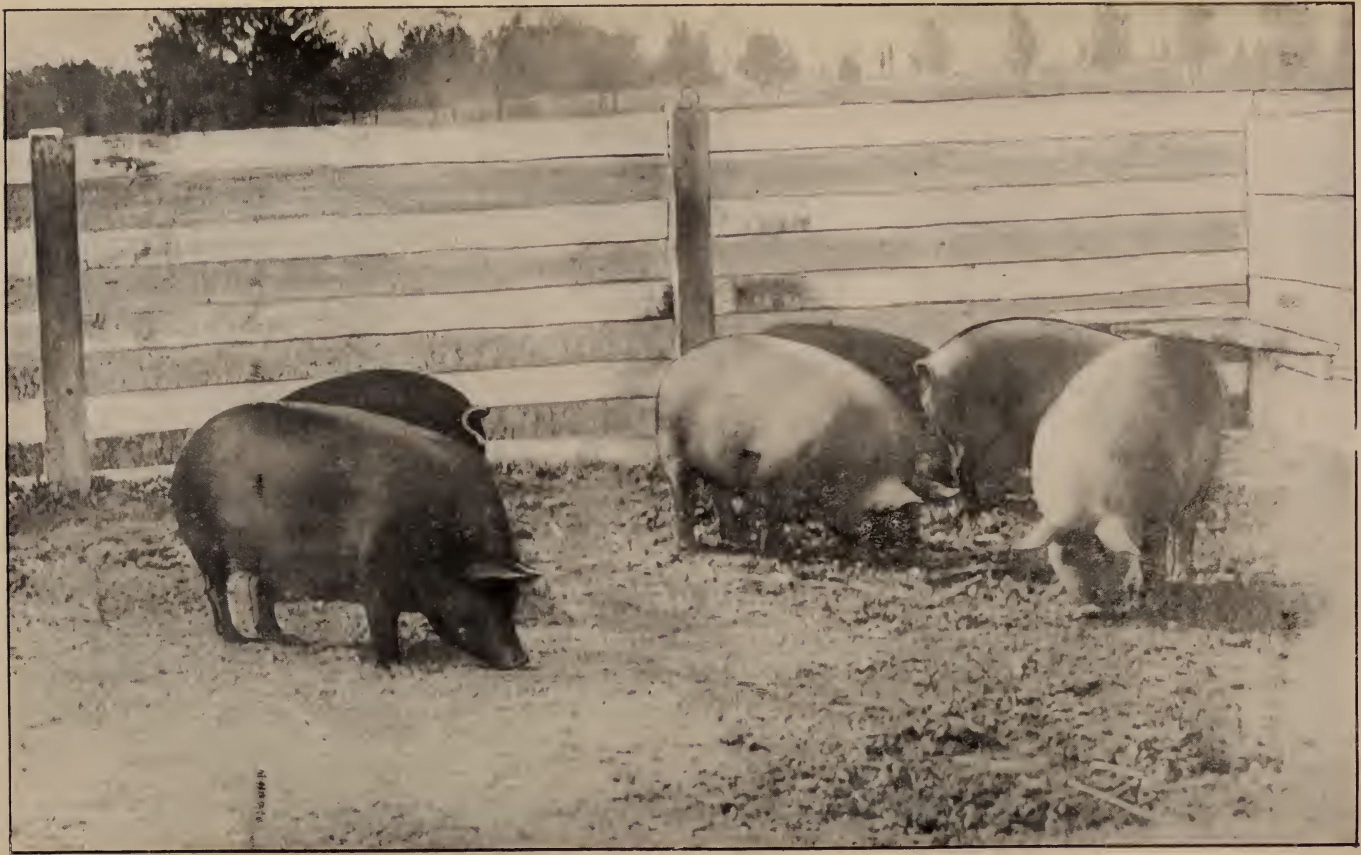
At the above prices for foods, the 596 lbs. of pork resulting from the food consumed by Lot B would cost $24.40 or $4.09 per Cwt. live weight.

Supposing that 4242 lbs. of grain produced 568 lbs. of pork in Lot B, or that it required 7.47 lbs. of grain to produce one lb. of pork, then the 4695 lbs of grain eaten by Lot A should have produced 628 lbs. of pork which would allow 617 lbs. of pork to be credited to the 18312 lbs. of milk consumed or 29.6 lbs. of milk to each one pound of pork. This would give a value of 14 cents per Cwt. for the milk.

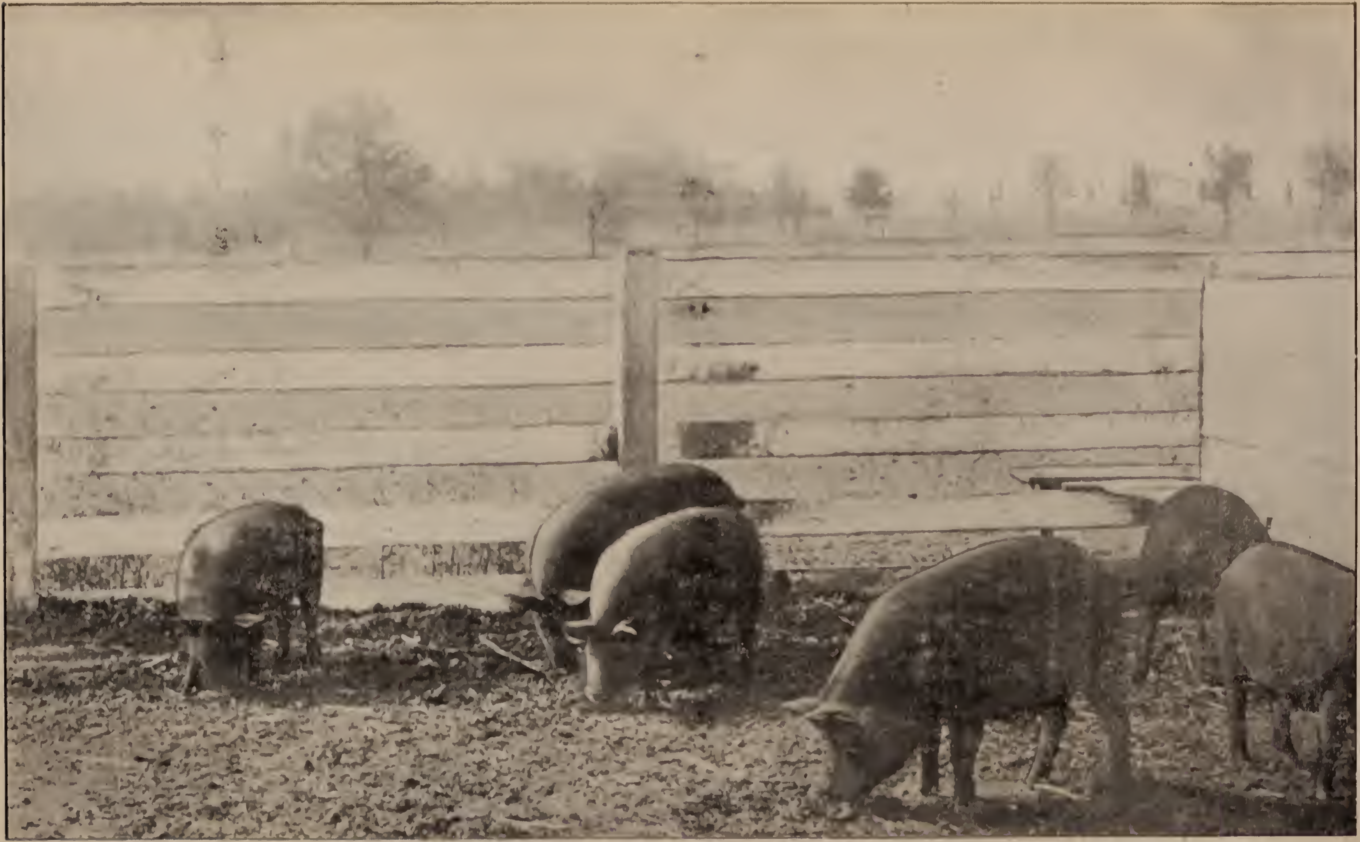
These figures and presumptions of course are not absolutely accurate, for no doubt both the milk and clover had an action in the animal economy of the rations consumed beyond what is represented by the digestible constituents; in fact the mixture of such foods materially contributes toward their digestibility and assimilation. The above results show that separator skim milk is valuable as a hog feed beyond the price ordinarily charged for the product at the creameries. It is not uncommon to find it hard for some creameries to dispose of all their skim milk at one cent per gallon or eleven and one-half cents per Cwt., and the charge at many of the creameries in this state is only ½ cent per gallon. At the price of one cent per gallon and with the gains made by Lot A of 1245 lbs., the cost would be $46.11 or $3.70 per Cwt. for the pork produced.

These pigs, it will be noticed, were 9 or 10 months old at the end of the experiment and that the heaviest weighed over 200 lbs. dressed, which, as will appear from later experiments is too long to keep pigs for the most profit and also as is well known, our markets prefer and pay most for pigs dressing about 150 lbs.

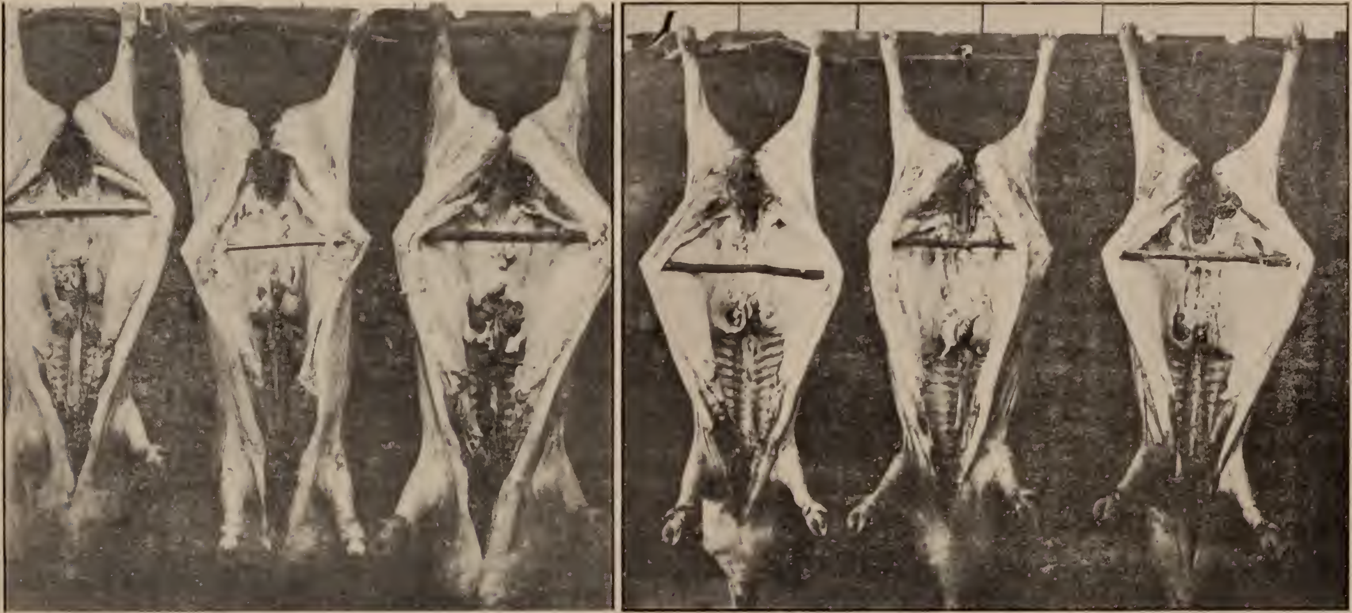
The following picture shows the two pens of pigs, and cross sections of the meat of some of the average pigs from each pen :



Pigs in Lot A—Picture taken at end of feeding experiment.

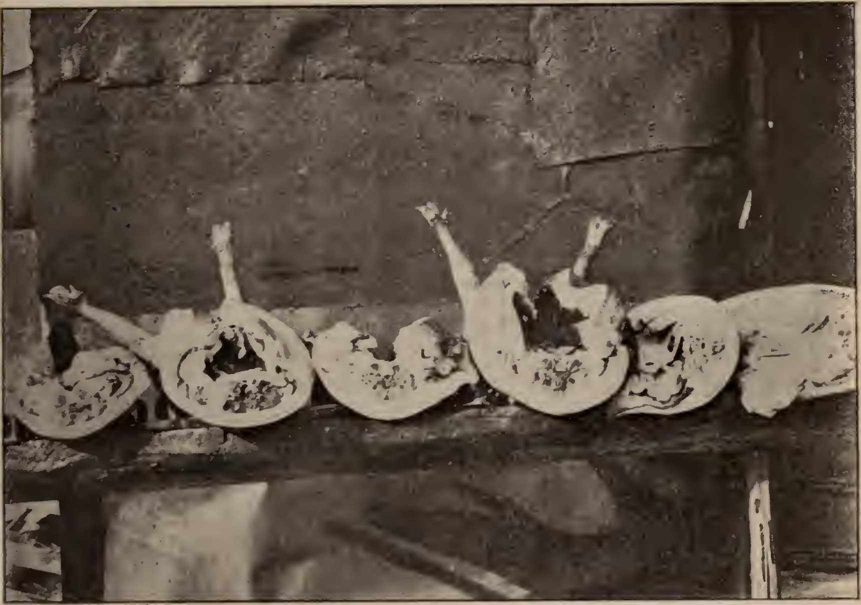


Pigs in Lot B—Picture taken at end of feeding experiment.

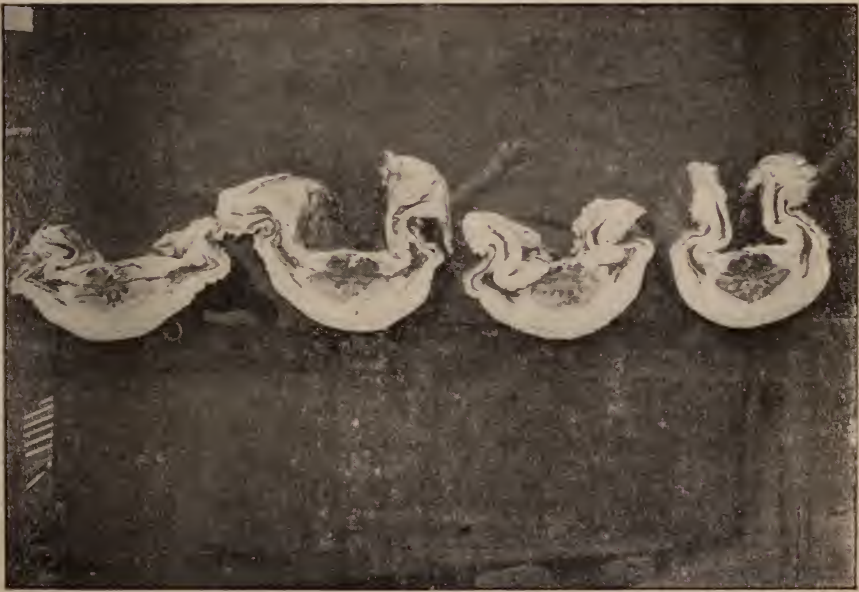


Lot A. Lot B.

Showing the average hogs from each lot after dressing.



Cross section of the meat in Lot B.



Cross section of the meat in Lot A.

# PIG FEEDING EXPERIMENT NO. 2.

## A COMPARISON OF THE USE OF SKIM MILK AND GLUTEN AND LINSEED MEALS FOR BALANCING A GRAIN RATION FOR PIGS.

This experiment consisted in balancing a grain ration consisting of a mixture of hominy chop and ground corn fodder (new corn product) for one lot of pigs with separator skim milk and for the other lot of pigs with a mixture of the by products gluten meal and linseed meal.

### EXPERIMENT NO. 2.

Lot C—Grain ration balanced with skim milk.

Lot D—Grain ration balanced with gluten and linseed meals.

Duration of experiment—December 1st 1896 to April 1, 1897.

The rations used were made up as follows:

TABLE VII.

*Ration fed Pigs in Lot C.*

| | | DIGESTIBLE | | |
|---|---|---|---|---|
| | Quantity. | Protein. | Carbohydrates | Fat |
| Hominy chop, | 300 | 26.7 | 185.7 | 18.9 |
| Gr'd fodder (new corn prodt) | 100 | 3.8 | 49.5 | 2.3 |
| Separator Skim Milk, | 2400 | 84.0 | 115.2 | 2.4 |
| Total. | 2800 | 114.5 | 350.4 | 23.6 |

Nutritive Ratio 1: 3.52.

In practice the grain ration was mixed up in quantity and at the time of feeding, the grain was mixed with milk and water to make a slop. There were approximately six pounds of milk fed for each one pound of the grain during the first two months and then the quantity was gradually reduced until the last month there were only three pounds of milk fed for each pound of grain.

TABLE VIII.

*Ration Fed to Pigs in Lot D.*

| | | DIGESTIBLE | | |
|---|---|---|---|---|
| | Quantity Pounds. | Protein Pounds. | Carbohydrates Pounds. | Fat Pounds. |
| Hominy Chop, | 300 | 26.7 | 185.7 | 18.9 |
| Ground Fodder, (N. C. P.) | 100 | 3.8 | 49.5 | 2.3 |
| Gluten Meal, (King) | 100 | 33.4 | 29.8 | 14.3 |
| Linseed Meal, | 200 | 58.6 | 65.4 | 14.0 |
| Total, | 700 | 122.5 | 330.4 | 49.5 |

Nutritive Ratio 1: 3.61.

This grain mixture was used in slop with water for feeding.

The ground fodder shives or the new corn product was introduced with these rations for the purpose of testing the value of coarse fodder in the hog's rations and to see if this particular kind of coarse fodder could be utilized for pigs. It is a well recognized fact, yet one that is very commonly ignored, that a pig's natural instinct is to graze and that it wants coarse matter as well as a grain diet. Those who are most successful at raising pigs and make pork at the least cost almost always graze their pigs or offer some substitute for it; therefore it would seem desirable to mix something with a grain ration as a substitute for the grazing, which is not practicable on many places.

The quantity of food consumed by the two Lots during the different months was as follows:

### TABLE IX

*Quantity of Food Consumed by Lots C. and D. by Periods.*

| | | LOT C. | | LOT D. |
|---|---|---|---|---|
| | Days | Milk. | Grain Mixture. | Grain Mixture. |
| December, 1896 | 31 | 3162 | 538 | 515 |
| January, 1897, | 31 | 3864 | 784 | 768 |
| February. 1897, | 28 | 3830 | 875 | 878 |
| March, 1897. | 31 | 3392 | 1168 | 1169 |
| Total. | 121 | 14248 | 3365 | 3330 |

The pigs used in this experiment were grade Berkshire and were purchased from William Shaw, Colesville, Montgomery county, Md., on October 26, 1896, and were about two months old. They were divided into two lots and fed on a preliminary ration for one month and then the experiment proper commenced December 1, 1896.

### TABLE X.

*Weights and Gains of Pigs in Lots C. and D., by Months, During Feeding Experiment. (Six Pigs in each Lot.)*

| | | | LOT C | | LOT D | |
|---|---|---|---|---|---|---|
| | | Days | Weight. | Gain | Weight. | Gain. |
| December | 1st | | 394 | ..... | 340 | |
| January | 1st | 31 | 686 | 292 | 524 | 175 |
| February | 1st | 31 | 964 | 278 | 727 | 203 |
| March | 1st | 28 | 1200 | 236 | 945 | 218 |
| April | 1st | 31 | 1514 | 314 | 1168 | 223 |
| Total | | 121 | | 1120 | | 819 |

| | | |
|---|---|---|
| Gain per Pig, | 186.7 | 136.5 |
| Gain per day per pig, | 1.54 | 1.12 |
| Average weight of pigs, | 252. | 195. |

Age of pigs at the end of the experiment:—7 months.

## DISCUSSION OF RESULTS OF FEEDING EXPERIMENT NO. 2.

In Lot C if we assume that it requires the same amount of milk to produce one pound of pork as was determined by Lot A in Experiment No. 1 or 29.6 pounds of milk to one pound of pork then the 14248 pounds of milk consumed by Lot C should have produced 481 pounds of pork which would have cost $19.95 allowing 14 cents per cwt. for the milk. Deducting the 481 pounds of pork produced by the milk from the total gain of 1120 pounds would give 639 pounds of pork to the credit of the 3365 pounds of grain mixture consumed. Allowing the same valuation for the 639 pounds produced by the grain as for that produced by the milk would make it equivalent to $26.52. Of the 3365 pounds of grain mixture consumed, 2524 pounds were hominy chop. This at the price that was paid for hominy chop had a value of $13.88 and would allow $12.64 as the value of the 841 pounds of ground fodder (new corn product) consumed in the ration. Of course all of these presumptions are not correct but show that such coarse provender as ground fodder (new corn product,) when put in a palatable form, has a value in rations for pigs beyond what is commonly recognized.

If we allow 14 cents per cwt. for separator skim milk; $11.00 per ton (actual cost) for hominy chop, and $11.00 per ton for the ground fodder (new corn product,) the pork produced would cost 3½c per pound; which shows that rations can be compounded so as to produce pork at a profit even when it is selling very low.

In Lot D, if we assume that it requires the same number of pounds of hominy chop and ground fodder to produce one pound of pork, that is 5.27 pounds of a mixture of 3 parts of hominy chop and 1 part ground fodder to produce one pound of pork, then the 1903 pounds of this mixture consumed by lot D would have 361 pounds of pork to its credit. This would leave a balance of 458 pounds of pork as produced by 1427 pounds of a mixture of 2 parts linseed meal and 1 part King gluten meal. Allowing the prices above quoted for hominy chop and the new corn product, and the cost price of the linseed meal to be $16.50 per ton, and gluten meal at $13.50 per ton would make the 819 pounds of gain for Lot D cost $20.52 or $2.51 per cwt. If we should calculate the separator skim milk consumed by Lot C at one cent per gallon, the common price at creameries, then the gain produced by this lot would cost $3.10 per cwt. Even at this price the ration balanced with the by products linseed meal and gluten meal would produce pork over one-half cent per pound cheaper than the ration balanced with skim milk. If same valuation was given for the cost of the pork produced by Lot C as by Lot D the value of the separator skim milk would be 6 cents per cwt. for balancing a ration, as compared to linseed and gluten meals at the above prices.

The following cut shows the average pigs from the two lots dressed.

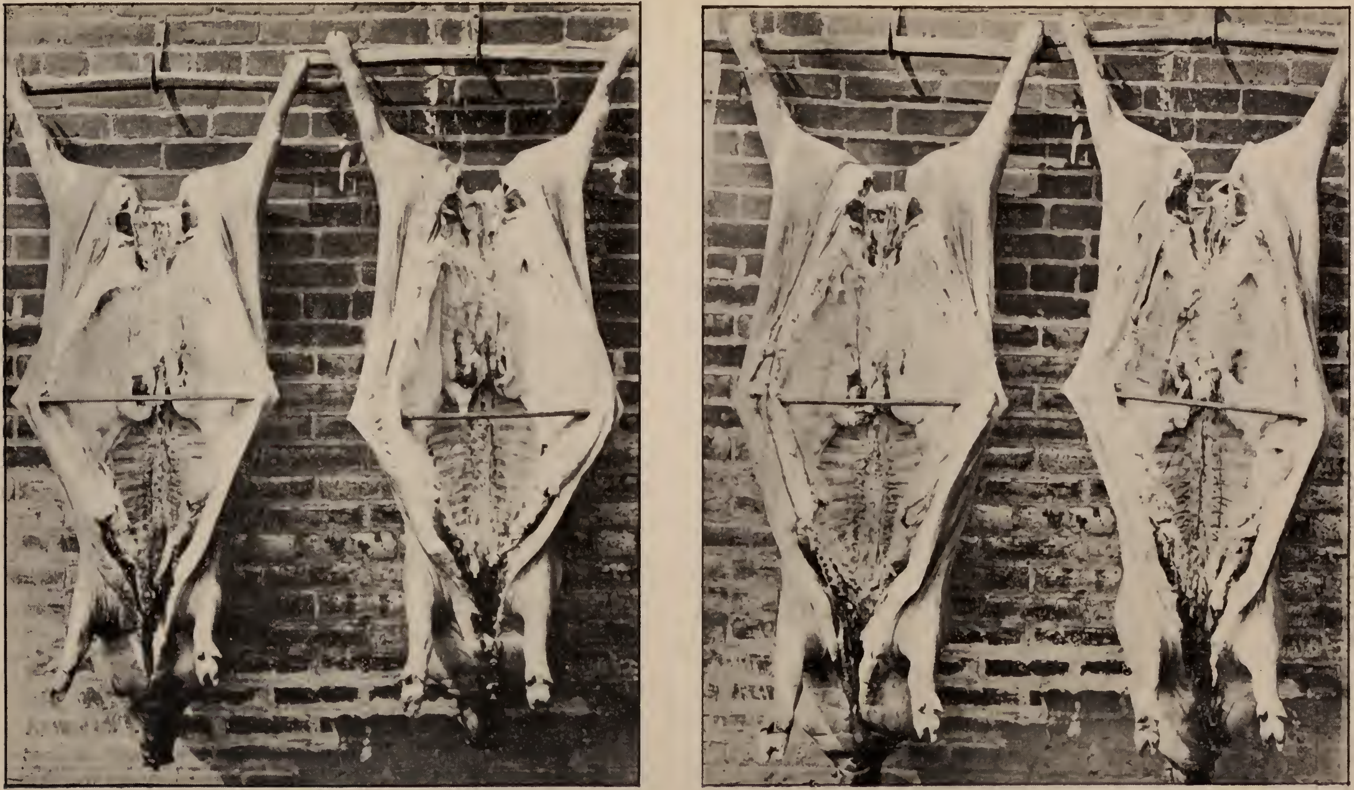
If we calculate the cost of the gain produced during the different feeding periods using the above basis for the cost of the grain feeds and one cent per gallon or eleven cents per cwt. for milk, we have the figures shown in the following table for the cost of one hundred pounds of pork during the different feeding periods.

## TABLE XI.

*Showing the Food Consumed, Gain in Weight and Cost of Gain per Hundred Pounds, by Periods.*

| Period. | Month | Days | ..... FOOD CONSUMED ..... | | Gain in weight Pounds | Cost of gain per cwt |
|---|---|---|---|---|---|---|
| | | | Milk Pounds | Grain Pounds | | |
| Lot C. | | | | | | |
| 1st | December | 31 | 3162 | 538 | 292 | $2 26 |
| 2d | January | 31 | 3864 | 784 | 278 | 3 15 |
| 3d | February | 28 | 3830 | 875 | 236 | 3 90 |
| 4th | March | 31 | 3392 | 1168 | 314 | 3 29 |
| Lot D. | | | | | | |
| 1st | December | 31 | ...... | 515 | 175 | 1 90 |
| 2d | January | 31 | ...... | 768 | 203 | 2 44 |
| 3d | February | 28 | ...... | 878 | 218 | 2 60 |
| 4th | March | 31 | ...... | 1167 | 223 | 3 38 |

It will be noticed from the data previously given that the pigs used in this experiment were sold at about seven months old when the average weight for both lots was 223 pounds, which is heavy enough for market. From the above table we see, with one exception, the older the pigs became the more they ate for a pound of gain and consequently the more it cost to product one hundred pounds of pork. From this the lesson should be learned that it is possible to make marketable pork of pigs but a few months old and that the most profit is made during the earlier months of the life of the pig.



Lot D. Lot C.

Showing the appearance of two average pigs from each lot after dressing.

# PIG FEEDING EXPERIMENT NO. 3.

## TESTING THE VALUE OF CORN FODDER AS A FOOD FOR PIGS.

The pigs used in this experiment were purchased in the open market in Washington, D. C., and to all appearances were about two months old and of very nearly the same breeding; but as they grew older and the experiment advanced the pigs showed themselves to be of very different breeding and the indications were that the most of the best bred pigs were in lot F. The pigs were fed a few days on a preliminary ration of chop and milk, and on April 10, divided into two lots as nearly as possible according to weights.

RATIONS USED—The rations used during this experiment were as follows:

TABLE XII.

*Ration fed Lot E.*

| Kind of Feed. | Quantity | DIGESTIBLE. | |
|---|---|---|---|
| | | Protein | Carbohydrates |
| Ground fodder (N.C. P.) | 200 | 7.6 | 109 8 |
| Hominy Chops | 500 | 35.5 | 397.5 |
| King Gluten Meal | 100 | 32.3 | 72.5 |
| Linseed Meal | 200 | 58.6 | 97.0 |
| Skim Milk | 2000 | 70.0 | 114.0 |
| | | 205.0 | 790.8 |

Nutritive Ratio 1: 3.87.

TABLE XIII.

*Ration fed Lot F.*

| Kind of Feed | Qnantity | DIGESTIBLE. | |
|---|---|---|---|
| | | Protein | Carbohydrates |
| Hominy Chop | 700 | 50 0 | 556 |
| Gluten Meal | 100 | 32 3 | 73 |
| Linseed Meal | 200 | 28 6 | 97 |
| Skim Milk | 2000 | 70.0 | 114 |
| | | 210.9 | 840 |

Nutritive Ratio 1: 3.98.

It will be noticed that the only difference in the ration was the substitution of 200 pounds of hominy chop by 200 pounds of ground fodder (new corn product) in the ration fed lot "E." This gave rations with approximately the same nutrition ratio, but that fed lot E, contained a little less protein and carbohydrates per hundred pounds of feed than that fed Lot F; but they were made as nearly the same in this respect as it was possible to do so. The ground fodder or new corn product was used, as it was the only convenient feed in the proper form which could be obtained.

The aim in feeding was to give, at all times, as much as the pigs could eat clean and with relish but never to over feed or allow feed to stand in the troughs.

## TABLE XIV.

*Showing the Amount of feed Consumed by Pigs by Periods, and the Quantity required for* 100 *pounds of Gain.*

Pigs fed from April 10th to July 10, 1897, (6 Pigs in each lot.)

| | .LOT E—6 PIGS... | | ....LOT F—6 PIGS.... | |
|---|---|---|---|---|
| | Grain & Fodder | Milk | Grain | Milk |
| Food Eaten, April 10th to May 10th | 512 | 1024 | 511 | 1022 |
| " " May 10th to June 10th | 758 | 1516 | 753 | 1506 |
| " " June 10th to July 10th | 974 | 1948 | 909 | 1818 |
| Total | 2244 | 4488 | 2173 | 4346 |
| Quantity of grain required for 100 ℔s of gain during first period. | 237 | 474 | 216 | 432 |
| Quantity of grain required for 100 ℔s of gain during second period. | 286 | 572 | 264 | 528 |
| Quantity of grain required for 100 ℔s of gain during third period. | 379 | 758 | 362 | 724 |
| Average | 304 | 608 | 281 | 562 |

## TABLE XV.

*Showing the Quantity of different parts of the Rations Consumed by Pigs in producing* 100 *pounds of Gain.*

| Quantity required to produce 100 pounds of gain | | ..............LOT E................ | | | ..........LOT F.......... | |
|---|---|---|---|---|---|---|
| | | Fodder | Grain | Milk | Grain | Milk |
| 1st period | 30 days | 47 | 190 | 474 | 216 | 432 |
| 2d period | 30 days | 57 | 229 | 572 | 264 | 528 |
| 3d period | 30 days | 76 | 306 | 758 | 362 | 724 |
| | Average | 61 | 243 | 608 | 281 | 562 |

## TABLE XVI.

*Showing the Weights and Gains of Pigs by periods.*

(Age of pigs at beginning of Experiment—Approximately 2 months.)

| | LOT E—6 PIGS | | LOT F—6 PIGS | |
|---|---|---|---|---|
| | Weight | Gain | Weight | Gain |
| Weight April 10th | 240 | | 240 | ..... |
| " May 10th | 456 | 216 | 477 | 237 |
| " June 10th | 21 | 265 | 762 | 285 |
| " July 10th | 970 | 257 | 1013 | 251 |
| Total 90 days | | 738 | | 773 |
| Average weight of Pigs at beginning of test | 40 | | 40 | |
| Average weight of Pigs at end of test | 163 | | 169 | |
| Average gain per pig | | 123 | | 129 |
| Average gain per pig per day | | 1.37 | | 1.43 |

## TABLE XVII.

*Showing the cost of producing 100 pounds of gain in pigs by periods and the value of ground corn fodder in their rations.*

| In producing 100 lbs of Gain | LOT E | | | | LOT E | | |
|---|---|---|---|---|---|---|---|
| | Calculated value of fodder | Cost of grain | Cost of milk | Total cost | Cost of grain | Cost of milk | Total cost |
| 1st Period | $0.08 | $1.20 | $0.55 | $1.83 | $1.33 | $0.50 | $1.83 |
| 2d " | . 3 | 1.45 | .66 | 2.24 | 1.63 | .61 | 2.24 |
| 3d " | .25 | 1.94 | .87 | 3.06 | 2.23 | .83 | 3.06 |
| Average | .14 | 1.54 | .70 | 2.38 | 1.74 | .64 | 2. 8 |

This would give a value for the ground fodder for the first period of $3.40 per ton, for the second period $4.56 per ton and for the third period $6.58, which would seem to indicate that the corn fodder has a greatest value for pigs as they grow older.

It is apparent from the above results that pork can be produced profitably from young pigs and that gains cost more as the pig grows in size and age.

The condition of the pigs made it undesirable to attempt to conduct this test for a longer time during the excessively hot weather which generally occurs during July and August in this lattitude.

# PIG FEEDING EXPERIMENT NO 4.

## TESTING THE VALUE OF COARSE FODDERS AS FOOD FOR PIGS.

(DECEMBER 1ST 1897 TO FEBRUARY 1ST 1898.)

This experiment was a repetition of No. 3, and was conducted as a check on that test, as there was some doubt as to the lots of pigs being of the same breeding and age as they ought to be for experimental work, and also with the idea of carrying the work on for a longer time in order to test the value of the coarse fodders for older pigs. This part of the experiment was cut short owing to these pigs contracting Hog Cholera from some infested pigs which were placed in the adjoining pen in the same house.

The pigs used in this experiment were purchased from Tarlton B. Stabler of Sandy Spring, Md., and were high grade Poland Chinas. They were brought to the Station on Nov. 5, at which time they were about seven weeks old. They represented two litters and there were six pigs of each litter. They were all fed together until Nov. 30th, when they were divided into two lots as nearly as possible by weight putting the same number from each litter in each lot. The experiment could be conducted with only five pigs to each lot, as one of them became sick.

The rations used in this test were precisely the same as those fed to Lots E and F (see page 22). The weights of the pigs and the food consumed are exhibited by the figures in the following table:

### TABLE XVIII.

*Total Food Consumed and Quantity Required for* 100 *lbs. of Gain.*

(PIGS WERE ABOUT TWO AND ONE-HALF MONTHS OLD AT BEGINNING OF EXPERIMENT.)

| | LOT G, 5 PIGS | | | LOT H, 5 PIGS | |
|---|---|---|---|---|---|
| | Fodder lbs | Grain lbs | Milk lbs | Grain lbs | Milk lbs |
| Total Food Consumed in Dec.—30 days. | 101 | 405 | 1012 | 512 | 1024 |
| Total Food Consumed in Jan.—30 days. | 129 | 518 | 1294 | 653 | 1306 |
| Quantity req'd to produce 100 lbs gain: | | | | | |
| 1st Period—30 days | 45 | 179 | 447 | 185 | 370 |
| 2nd Period—30 days | 80 | 321 | 803 | 304 | 607 |

## TABLE XIX.

*Showing Cost of Food Required for* 100 *pounds Gain.*

| LOT G. | | | | LOT H. | | |
|---|---|---|---|---|---|---|
| Calculated value of fodder | Cost of Grain | Cost of milk | Total Cost | Cost of grain | Cost of milk | Total Cost |
| 00 | 1 14 | 51 | 1 65 | 1 14 | 42 | 1 56 |
| 00 | 2 04 | 92 | 2 96 | 1 88 | 69 | 2 57 |

## TABLE XX.

*Weights and Gains of Pigs by Periods. Test No.* 4.

| | LOT G, 5 PIGS | | LOT H, 5 PIGS | |
|---|---|---|---|---|
| | Weight lbs | Gain lbs | Weight lbs | Gain lbs |
| Weight December 1st. | 307 | .... | 295 | .... |
| Weight December 31st, | 533 | 226 | 571 | 276 |
| Weight January 30th, | 694 | 161 | 786 | 215 |
| Total Gain in 60 days, | .... | 387 | .... | 491 |
| Average wt of pigs at beginning of test | 61 | .... | 59 | .... |
| Average wt. of pigs at end of test | 139 | .... | 157 | .... |
| Average gain per pig | .... | 87 | .... | 98 |
| Aversge gain per pig per day | .... | 1 30 | .... | 1.63 |

The results obtained in this experiment show that the addition of the fodder in the quantity fed was of no advantage but rather of a slight disadvantage for pigs of the ages used in this test.

All the data of this test confirm that of other tests on the point of the rapid increase of cost in the production of a pound of gain with the advance of age. The results of tests Nos. 3 and 4 indicate that it would be desirable to repeat this line of work and make a test with using different proportions of the coarse fodder and older pigs. This is taken up in Experiment No. 5.

# PIG FEEDING EXPERIMENT NO. 5.

## TESTING THE VALUE OF DIFFERENT QUALITIES OF COARSE FODDER IN RATIONS FOR PIGS.

This experiment was a repetition of Nos. 3 and 4 with the addition of two lots of pigs to which different amounts of the ground fodder were given in order to get some data as to the proper proportion in which this class of matter should enter into a ration for pigs.

The pigs used in this test were Poland Chinas purchased from Tarlton B. Stabler, of Sandy Spring, Md. At the time of beginning the test they were from 10 to 12 weeks old and the pigs were divided into 4 lots of five pigs each, and so divided as to give the same number (5 pigs) from each litter in each lot, and also so as to give pigs of nearly the same weight to each lot.

RATIONS USED:—The rations used for lots "I" and "J" were the same as used for lots E and F, respectively. Those for lots "K" and "L" contained respectively ¼ and ½ less of the ground fodder. The aim was to feed two pounds of the milk to each one pound of the other part of the ration; but, owing to the scarcity of the milk, it was not possible to give the full allowance after the first month. At the beginning of the second month of the experiment, one pig in lot J fell suddenly sick and had to be cut out of the experiment. The trouble seemed to be rheumatic, the pig being stiff and not able to move about. The amount of food consumed by the several lots is shown in the following table.

TABLE XXI.

*Total Food Consumed and Quantity Required for 100 pounds of Gain.*

(BY PERIODS.)

| | LOT I 5 PIGS | | | LOT J 4 PIGS | | |
|---|---|---|---|---|---|---|
| | Fodder | Grain | Milk | Fodder | Grain | Milk |
| July, 31 days | 73 | 290 | 713 | ...... | 232 | 457 |
| August, 31 days | 97 | 391 | 742 | ...... | 258 | 402 |
| September, 30 days | 104 | 419 | 429 | ...... | 403 | 299 |
| October, 30 days | 116 | 458 | 426 | ...... | 320 | 277 |
| Total, 122 | 390 | 1558 | 2310 | | 1213 | 1435 |
| Quantity of milk fed to each pound of grain. | | | 1 2 | | | 1 2 |
| Quantity required for each 100 lbs. gain | | | | | | |
| 1st period | 46 | 182 | 448 | ...... | 176 | 346 |
| 2nd period | 62 | 251 | 475 | ...... | 255 | 398 |
| 3rd period | 91 | 367 | 376 | ...... | 363 | 269 |
| 4th period | 116 | 458 | 426 | ...... | 628 | 543 |
| Average | 74 | 295 | 437 | ..... | 307 | 363 |

Combining the data of Tables XXI and XXV, the cost of one pound of gain is exhibited in the following table :

## TABLE XXII.

*Cost and Value of Food consumed for one hundred pounds of Gain.*

| | LOT I | | | | LOT J | | | |
|---|---|---|---|---|---|---|---|---|
| | Calculated value of fodder | Cost of grain | Cost of milk | Total Cost | Cost of fodder | Cost of grain | Cost of milk | Total Cost |
| 1st Period | (-.23) | $1 70 | $0 52 | $2 22 | ...... | $1 60 | $0 39 | $1 99 |
| 2nd Period | (-.11) | 2 35 | 54 | 2 89 | ...... | 2 32 | 46 | 2 78 |
| 3d Period | (-.25) | 3 43 | 43 | 3 86 | ...... | 3 30 | 31 | 3 61 |
| 4th Period | 1.55 | 4 28 | 49 | 6 32 | ...... | 5 70 | 62 | 6 32 |
| Average | (-. 5) | 2 76 | 50 | 3 26 | ...... | 2 79 | 42 | 3 21 |

## TABLE XXIII.

*Food Consumed and Quantity required for* 100 *pounds of Gain.*

(BY PERIODS.)

| | | LOT K, 5 PIGS | | | LOT L, 5 PIGS | | |
|---|---|---|---|---|---|---|---|
| | | Fodder | Grain | Milk | Fodder | Grain | Milk |
| July | 31 days | 55 | 312 | 721 | 38 | 337 | 738 |
| August | 31 days | 75 | 426 | 789 | 50 | 451 | 815 |
| September | 30 days | 75 | 427 | 432 | 54 | 486 | 443 |
| October | 30 days | 78 | 445 | 426 | 58 | 527 | 400 |
| Total | | 283 | 1610 | 2368 | 200 | 1801 | 2396 |
| Quantity of milk in lbs. fed to one lb. other feed. | | | | 1 25 | | | 1 2 |
| Quantity required for 100 lbs. gain | | | | | | | |
| 1st Period | | 32 | 180 | 417 | 20 | 179 | 393 |
| 2nd Period | | 40 | 230 | 426 | 29 | 267 | 482 |
| 3rd Period | | 75 | 427 | 432 | 43 | 389 | 354 |
| 4th Period | | 104 | 593 | 568 | 62 | 567 | 430 |
| Average | | 53 | 303 | 445 | 35 | 313 | 417 |

From the data contained in table XXIII together with the gains as shown bytable XXV the cost per pound of gain is obtained as given in the following table:

## TABLE XXIV.

*Cost and Value of Food consumed for* 100 *pounds of gain.*

| | LOT K. | | | | LOT L. | | | |
|---|---|---|---|---|---|---|---|---|
| | Calculated value of fodder | Cost of grain | Cost of milk | Total Cost | Calculated valueof fodder | Cost of grain | Cost of milk | Total Cost |
| 1st Period | (-.16) | $1 67 | $0 48 | $2 15 | (-.11) | $1 65 | $0 45 | $2 10 |
| 2nd Period | .16 | 2 13 | 49 | 2 78 | (-.23) | 2 46 | 55 | 3 01 |
| 3rd Period | (-.86) | 3 97 | 50 | 4 47 | (- 38) | 3 58 | 41 | 3 99 |
| 4th Period | .17 | 5 50 | 65 | 6 32 | .61 | 5 22 | 49 | 6 32 |
| Average | (-.11) | 2 81 | 51 | 3 32 | (-.15) | 2 88 | 48 | 3 36 |

TABLE XXV.

*Weights and Gains of pigs. by periods. Lots I, J, K and L.*

| | | LOT I, 5 PIGS | | LOT J, 4 PIGS | | LOT K, 5 PIGS | | LOT L, 5 PIGS | |
|---|---|---|---|---|---|---|---|---|---|
| | | Wt lbs | Gain lbs | Wt lbs | Gain lbs | Wt lbs | Gain lbs | Wt lbs | Gain lbs |
| July 1, | 31 days | 199 | .... | 166 | .... | 204 | .... | 200 | .... |
| Aug. 1, | 31 days | 358 | 159 | 298 | 132 | 377 | 173 | 388 | 188 |
| Sept. 1, | 30 days | 514 | 156 | 399 | 101 | 562 | 185 | 557 | 169 |
| Oct. 1, | 30 days | 628 | 114 | 510 | 111 | 661 | 99 | 682 | 125 |
| Oct. 31, | ... | 727 | 99 | 561 | 51 | 736 | 75 | 775 | 93 |
| Total gain | 122 days | .... | 528 | .... | 395 | .... | 532 | .... | 575 |
| Average weight of pigs at beginning of test | | 39.8 | | 41 | | 41 | | 40 | |
| Average weight of pigs end of test | | 145.4 | | 140 | | 147 | | 155 | |
| Average gain per pig | | | 105 6 | | 99 | | 106 | | 115 |
| Average gain per pig per day | | | 0.87 | | 0.81 | | 0.87 | | 0 94 |

The results exhibited by the above figures, when taken in connection with those of Experiments Nos. 3 and 4 show the need for more data on many points before definite conclusions could be drawn; but they indicate that the coarse fodders are better adapted to the older and larger pigs and that small pigs should receive smaller proportions of the coarse feed. In Experiment No. 5, all the rations containing fodder proved to be very advantageous after the pigs were six months old.

The experiments, so far, show the best results with coarse fodder when fed in the absence of milk, and this would seem to indicate that these two feeds in some respects supply certain of the same requirements in the animal economy, and that where milk is used there is less requirement for the coarse fodder or supplying some substitute for the grazing portion of the pigs' rations. This indication is also borne out by the facts observed in feeding pigs throughout the whole country, that is that pen pigs receiving milk in addition to other rations, thrive out of proportion to the food contents of the milk.

# PIG FEEDING EXPERIMENT NOS. 6 AND 7.

## A COMPARISON OF THE USE OF GLUTEN MEAL AND LINSEED MEAL FOR BALANCING HOG RATIONS; BOTH WITH AND WITHOUT THE ADDITION OF COARSE GROUND FODDER.

The pigs used in this Experiment were high grade Poland Chinas, purchased from Tarlton B. Stabler, of Sandy Spring, Md.

They were brought to the Station November 19th, and were all fed alike until December 1st, when they were divided into four lots according to size and also so as to give the same number from each litter in each lot. The pigs represented three different litters and were practically the same age or about eight weeks old when they arrived at the Station. There were eight pigs from litter No. 1; eight pigs from litter No. 2; and four pigs from litter No. 3.

RATIONS USED:—For the first two months of the Experiment Lots "M" and "N" received the same ration, which consisted of a mixture of hominy chop and linseed meal, and Lots "O" and "P" received the same ration which was a mixture of hominy chop and "King" gluten meal. Each lot received one pound of milk to each pound of grain mixture fed.

RATIONS FOR LOTS M and N.

| | Quantity pounds | . . . . DIGESTIBLE<br>Protein pounds | . . . .<br>Carbohydrates pounds |
|---|---|---|---|
| Hominy Chop, | 600 | 42.6 | 477 |
| Linseed Meal, | 400 | 117.2 | 198 |
| | 1000 | 159.8 | 675 |

Nutritive ratio, 1:4.2.
Cost of above mixture $20.00 per ton.

RATIONS FOR LOTS O and P.

| | Quantity pounds | . . . . DIGESTIBLE<br>Protein pounds | . . . .<br>Carbohydrates pounds |
|---|---|---|---|
| Hominy Chop, | 600 | 42.6 | 477 |
| Gluten Meal, (King) | 400 | 114.8 | 268 |
| | 1000 | 157.4 | 745 |

Nutritive Ratio, 1:4.7.

Cost of above mixture, $16.60 per ton.

The cost of the feeds used in the test were as follows:

| | | |
|---|---|---|
| Hominy Chop, | $16.00 | per ton |
| Gluten Meal, | $16.50 | per ton |
| Linseed Meal, | $26.00 | per ton |

## TABLE XXVI

*Showing the Quantity of Grain and Milk Consumed and Amount Required for 100 pounds of gain. By periods.*

| | LOT M, 5 PIGS | | LOT N, 5 PIGS | | LOT O, 5 PIGS | | LOT P, 5 PIGS | |
|---|---|---|---|---|---|---|---|---|
| | Grain | Milk | Grain | Milk | Grain | Milk | Grain | Milk |
| December | 282 | 282 | 278 | 278 | 255 | 255 | 248 | 248 |
| January | 442 | 442 | 434 | 434 | 308 | 308 | 317 | 317 |
| Total | 724 | 724 | 712 | 712 | 563 | 563 | 565 | 565 |
| Quantity of food required for 100 lbs gain | | | | | | | | |
| December | 198 | 198 | 238 | 238 | 300 | 300 | 430 | 430 |
| January | 285 | 285 | 245 | 245 | 197 | 197 | 159 | 159 |
| Average | 242 | 242 | 242 | 242 | 233 | 233 | 220 | 220 |

## TABLE XXVII.

*Showing the cost of producing 100 pounds of Gain. Linseed Meal vs. Gluten Meal as a Ration.*

| Period | LOT M—Linseed | | | LOT N—Linseed | | | LOT O—Gluten | | | LOT P—Gluten | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost of Grain | Cost of Milk | Total Cost | Cost of Grain | Cost of Milk | Total Cost | Cost of Grain | Cost of Milk | Total Cost | Cost of Grain | Cost of Milk | Total Cost |
| 1st | $1 98 | $0 23 | $2 21 | $2 38 | $0 27 | $2 65 | $2 49 | $0 .34 | $2 83 | $3 57 | $0 49 | $4 06 |
| 2nd | 2 85 | 33 | 3 18 | 2 45 | 28 | 2 73 | 1 63 | 23 | 1 86 | 1 32 | 18 | 1 50 |
| Average | 2 43 | 28 | 2 71 | 2 42 | 28 | 2 70 | 1 93 | 27 | 2 20 | 1 82 | 25 | 2 07 |

Average Cost of 100 lbs. of Gain by Pigs fed on Linseed Meal Ration $2.70.
Average Cost of 100 lbs. of Gain by Pigs fed on Gluten Meal Ration $2.13.

## TABLE XXVIII.

*Showing Weights and gains of pigs by periods.*

| | LOT M, 5 PIGS | | LOT N, 5 PIGS | | LOT O, 5 PIGS | | LOT P, 5 PIGS | |
|---|---|---|---|---|---|---|---|---|
| | Wt | Gain | Wt | Gain | Wt | Gain | Wt | Gain |
| December 1st | 187 | .... | 180 | .... | 182 | .... | 185 | .... |
| December 31st | 330 | 143 | 297 | 117 | 267 | 85 | 241 | 56 |
| January 31st | 485 | 155 | 474 | 177 | 423 | 156 | 441 | 200 |
| Total | .... | 298 | .... | 294 | .... | 241 | .... | 256 |
| Average wt. of pigs at beginning | 37.4 | | 36.0 | | 36 4 | | 37.0 | |
| Average wt. of pigs at end | 97.0 | | 94.8 | | 84 6 | | 88.2 | |
| Average wt. per pig | | 59.6 | | 58.8 | | 48.2 | | 51.2 |
| Gain per pig per day | | 0.99 | | 0.98 | | 0 80 | | 0.85 |

The results obtained above show cheaper gains for the first month with the linseed meal but the average for the two months was in the favor of the gluten meal as far as cost of production is concerned while the linseed meal produced a slightly greater gain.

On February 1st the rations for Lots N and P had 250 pounds of ground fodder substituted for 250 pounds of hominy chop in each ton of the mixture. The same rations were continued for Lots M and O.

The composition of rations N and P are shown in the following table:

### TABLE XXIX.

*Rations Fed Lot N from February 1st to May 1st*, 1899.

| | Quantity pounds | DIGESTIBLE Protein pounds | Carbohydrates pounds |
|---|---|---|---|
| Ground Fodder (N. C. P.) | 250 | 9.4 | 137 |
| Hominy Chop, | 950 | 67.4 | 755 |
| Linseed Meal, | 800 | 234.4 | 396 |
| | 2000 | 311.2 | 1288 |

Nutritive Ratio, 1:4.1.

Cost of above mixture without the fodder, $18.00.

### TABLE XXX.

*Ration fed Lot* P *from February 1st to May 1st*, 1899.

| | Quantity pounds | DIGESTIBLE Protein pounds | Carbohydrates pounds |
|---|---|---|---|
| Ground Fodder (N. C. P.) | 250 | 9.4 | 137 |
| Hominy Chop, | 950 | 67.4 | 755 |
| Gluten Meal ("King") | 800 | 229.6 | 536 |
| | 2000 | 306.4 | 1428 |

Nutritive Ratio, 1:4.6.

Cost of the above mixture without the fodder, $14.60.

In addition to the grain rations, all lots received one pound of Separator skim milk to each pound of the mixture fed.

The pigs receiving the rations to which fodder had been added, ate well and gave no trouble at any time; but the same pigs in those lots receiving the rations without the fodder were, at times, considerably indisposed. The trouble partook of the nature of a rheumatic lameness accompanied by refusing to eat and consequently had to be cut out of the experiment at the times indicated by the following notes: Necessary allowances for feed had to be calculated.

NOTE 1:—On Sept. 18th a pig (barrow) weighing 110 lbs. was cut out of pen M, on account of protruding intestine. This pig was in good health otherwise and ate well at all times.

NOTE 2:—On April 10th a pig weighing 148 lbs. was cut out of pen M on account of lameness and loss of appetite.

NOTE 3:—On April 10th a pig weighing 119 lbs. was cut out of pen O on account of lameness and loss of appetite.

NOTE 4:—On April 22nd a pig weighing 145 lbs. was cut out of pen O on account of lameness and loss of appetite.

It will be noted that all of the pigs having this rheumatic trouble were in those lots receiving the heavy, compact and concentrated rations. This was also true of the pig which was cut out of lot J in experiment No. 5.

## TABLE XXXI.

*Showing the weights and gains of pigs. Experiments M to R.*

| | ......LOT M. .... | | LOT N, 5 PIGS | | ......LOT O...... | | LOT P. 5 PIGS | |
|---|---|---|---|---|---|---|---|---|
| | Weight lbs | Gain lbs | Wt. lbs | Gain lbs | Weight lbs | Gain lbs | Wt. lbs | Gain lbs |
| | 4 pigs | | | | 5 pigs | | | |
| January 31st | 384 | .... | 474 | .... | 423 | .... | 441 | .... |
| March 1st | 497 | 113 | 551 | 77 | 561 | 138 | 526 | 85 |
| March 31st | 564 | 67 | 696 | 145 | 746 | 185 | 673 | 147 |
| | 3 pigs | | | | 3 pigs | | | |
| March 31st | 410 | .... | .... | .... | 497 | .... | .... | .... |
| May 1st | 470 | 60 | 802 | 106 | 560 | 63 | 790 | 117 |
| Total gain 90 days | | 240 | | 328 | | 386 | | 349 |
| Avr. wt. at beginning | | | 95 | | | | 88 | |
| Average wt. at end | | | 160 | | | | 158 | |
| Gain per pig | | | | 65.6 | | | | 69.8 |
| Gain per pig per day | | | | 0.73 | | | | 0.77 |

## TABLE XXXII.

*Showing the Food Consumed and amount required for* 100 *lbs. of Gain.*

| | LOT M, Lin'd | | ...LOT N, Linseed... | | | LOT O, Glu'n | | ....LOT P, Gluten... | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Milk | Fodder | Grain | Milk | Grain | Milk | Fodder | Grain | Milk |
| February | 380 | 380 | 43 | 304 | 347 | 389 | 389 | 32 | 227 | 259 |
| March | 382 | 382 | 61 | 429 | 490 | 529 | 529 | 55 | 382 | 437 |
| April | 236 | 77 | 74 | 519 | 180 | 297 | 101 | 63 | 440 | 152 |
| Total | 998 | 839 | 178 | 1252 | 1017 | 1215 | 1019 | 150 | 1049 | 848 |
| | Quantity of Food Required for 100 lbs. Gain. | | | | | | | | | |
| February | 336 | 336 | 56 | 395 | 451 | 282 | 282 | 38 | 267 | 305 |
| March | 570 | 570 | 42 | 296 | 338 | 286 | 286 | 37 | 260 | 297 |
| April | 393 | 128 | 70 | 490 | 170 | 471 | 160 | 54 | 276 | 130 |
| Average | 416 | 350 | 54 | 382 | 310 | 315 | 264 | 43 | 301 | 243 |

## TABLE XXXIII.

*Showing the Cost of producing* 100 *lbs. gain. By Periods.*

| | .........LOT M, Linseed......... | | | LOT N, Linseed Meal and Fodder... | | | |
|---|---|---|---|---|---|---|---|
| | Cost of Grain | Cost of Milk | Total Cost | Estimated value of fodder | Cost of Grain | Cost of Milk | Total Cost |
| February | $3 36 | $0 39 | $3 75 | (-.32) | $3 55 | $0 52 | $4 07 |
| March | 5 70 | 65 | 6 35 | 3.30 | 2 66 | 39 | 6 35 |
| April | 3 93 | 15 | 4 08 | (-.52) | 4 41 | 19 | 4 60 |
| Average | 4 16 | 40 | 4 56 | .76 | 3 44 | 36 | 4 56 |
| | .........LOT O, Gluten......... | | | .........LOT P, Gluten and Fodder......... | | | |
| February | 2 34 | 32 | 2 66 | $0 36 | 1 95 | 35 | 2 66 |
| March | 2 37 | 33 | 2 70 | 46 | 1 90 | 34 | 2 70 |
| April | 3 91 | 18 | 4 09 | 2 20 | 2 74 | 15 | 4 09 |
| Average | 2 61 | 30 | 2 91 | 43 | 2 20 | 28 | 2 91 |

With the Linseed ration the fodder showed an estimated value of $28.00 per ton, and with the Gluten ration an estimated value of $20.00 per ton.

If the fodder is not taken into consideration, the average cost for producing 100 lbs. of gain with the Linseed ration was $4.18 and with the Gluten ration $2.70.

### DISCUSSION OF RESULTS OF EXPERIMENTS NOS. 6 AND 7.

The results brought out by the above figures show, that while linseed meal seems to be better adapted to young pigs, such as those used at the beginning of this experiment, yet this was merely a temporary condition, and that by the end of the second feeding period the gluten meal was in the lead both as to the rate of gain and as to the cost of producing the same. At the prices of the feeds at the time of making the tests the gluten meal was by far the more economical, which would also be true for the relative ruling prices of these feeds for the past several years. Anyone can easily make the calculation as to which would be the cheaper in an individual case by substituting the prices in the local markets in the above calculation.

The introduction of the coarse ground fodder (new corn product) in the rations "N" and "P" in this experiment had two noticeable effects; first to materially lessen the amount of the other foods consumed per hundred pounds of gain and so produce it at less cost, or, what is the same thing, give a very good return price for the fodder consumed; second, aside from the economy in the gain produced, the addition of the fodder to the concentrated and compact rations seemed to add materially to the health of the animals and make them endure the higher feeding. This was true in the lots of Pigs (J., N, and P).

This test also conforms to the earlier tests with coarse fodder that it was better adapted to pigs of more advanced age and otherwise more mature, and with such pigs it is really a necessity for the best and most economical results.

From all these tests it would seem to be desirable to mix with hog rations some material as a substitute for grazing when feeding pigs in confinement or if it is not possible to have a material that will mix well with the grain ration,finely cut fodder or other vegetable material may serve equally well as a substitute. Finely cut or ground clover or pea vine hay would possibly be a better coarse feed for pigs than the ground food used in these tests, as they contain more nitrogenous food matter and are also more easily digestible.

# PIG FEEDING EXPERIMENTS NOS. 8 TO 12

## A COMPARISON OF GRAIN RATIONS WITH PASTURAGE ON COW PEAS; PASTURAGE ON ARTICHOKE; RATIONS OF SWEET POTATO STRINGS.

## PIGS OF DIFFERENT AGES USED IN THESE TESTS.

(Duration of Experiment June 1st to December 1st 1899.)

The pigs used in these experiments were 20 Poland Chinas purchased on May 29th from Tarlton B. Stabler of Sandy Spring and 10 Poland Chinas and Chester Whites purchased August 12th from Edward Scott of Holland's Corner.

The Pigs were numbered from one to thirty and marked with the Wilcox Aluminum Ear Tags with the hopes of being able to follow the individual pigs, but this was not entirely satisfactory as some pigs lost their ear tags. The pigs were all about 8 weeks old at the time of purchase.

In the experiments Nos. 8 to 12, the pigs purchased on May 29th were divided on June 30th, into four lots (Q,R,S,T) of five pigs each so as to give the same number from each litter to each lot and also so as to start with the lots of nearly the same weight.

Lot Q was used as a check lot and kept in the pen, a complete record being made of all feed consumed.

The ration fed to lot Q from July 1st to November 1st was made up as follows:

| | | |
|---|---|---|
| Ground Fodder, | 50 | pounds. |
| Wheat Bran, | 150 | " |
| Hominy Chop, | 200 | " |
| Gluten Meal, | 100 | " |
| Total, | 500 | " |

To this was added 20 pounds of milk to each pound of grain fed during July, and from August 1st to October 1st there was fed one pound of milk to each pound of grain mixture. After October 1st there was no milk fed to these pigs.

During July, August and September lot R received the same ration as was fed to lot Q, and lots S and T received the same ration as Q during July and August. These periods gave a test of the individuality of the several lots. The cost of the above ration at the prices paid for the feed which entered into it was 80 cents per hundred pounds and as these results are not for direct comparison with those in tests Nos. 1 to 7, the basis for estimating the cost of the gains will be made on the rate of the actual cost at this time rather than the cost at the time of conducting the earlier tests.

## TABLE XXXIV.

*Results of Feeding Experiment with Lot Q. showing Gains Produced and Food Consumed and Cost of same. (5 Pigs in Each Lot.)*

| | Wt. lbs | Gain lbs | FOOD EATEN | | FOOD REQ,D FOR 100 lbs GAIN | | COST OF 100 POUNDS GAIN | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain | Milk | Grain | Milk | Grain | Milk | Total |
| June | 249 | .... | .... | .... | .... | .... | ...... | ...... | ...... |
| July | 362 | 113 | 355 | 710 | 314 | 628 | $2.51 | $0.70 | $3.21 |
| August | 466 | 104 | 411 | 411 | 395 | 395 | 3.16 | .43 | 3 59 |
| September | 605 | 139 | 495 | 495 | 356 | 356 | 2 85 | .39 | 3.24 |
| October | 671 | 66 | 668 | .... | 1012 | .... | 8.10 | ...... | 8.10 |
| November | 793 | 122 | 1030* | .... | 844 | .... | 3 00 | ..... | 3.00 |
| Average weight per pig at beginning | 49.8 | | | | | | | | |
| Average weight per pig at end | 158 6 | | | | | | | | |

*Feed: Corn on tne ear.

The results exhibited in the above table show that for the first three months of feeding the average cost of 100 pounds of gain was $3.32, or that with high priced feeds pork can be produced below the common selling price. The very high cost of the gains produced in October are not reasonable, but are one of those variations that occur and yet cannot be explained in experimenting with animals. This was probably due to some variation in the stomach contents at weighing time from the indications of the gains made during the following month.

The gains made with Lot Q during November, when the feed grain was only ear corn, was very satisfactory and substantiated the general belief and recommendation that the exclusive corn ration is good and economical for the finishing-off period of fattening pigs

## TABLE XXXV.

*Result of Feeding Experiment with Lot R. Showing the Gains Produced, Food Consumed, and cost of same. 5 Pigs in the Lot.*

| | Wt lbs | Gain lbs | FOOD EATEN | | FOOD REQ'D FOR 100 lbs GAIN | | COST OF 100 ....POUNDS GAIN.... | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain | Milk | Grain | Milk | Grain | Milk | Total |
| June | 248 | .... | ... | .... | .... | .... | .... | .... | ...... |
| July | 332 | 84 | 300 | 600 | 357 | 715 | $2 85 | $0.79 | $3.64 |
| August | 448 | 116 | 341 | 682 | 294 | 588 | 2 35 | .55 | 2.90 |
| September | 593 | 145 | 451 | 902 | 311 | 622 | 2.49 | .68 | 3.17 |
| October | 606 | 13 | 1380 | .... | 10616 | .... | .... | .... | ...... |
| November | 606 | 0 | 1622 | .... | ? | .... | .... | .... | ...... |
| Average weight per pig at beginning | 49.6 | | | | | | | | |
| Average weight per pig at end. | 121 2 | | | | | | | | |

## TESTING THE VALUE OF SWEET POTATO STRINGS FOR PIGS.

The pigs in Lot R were fed for three months the same grain ration as Lot Q, and a comparison of Tables XXXIV and XXXV shows that the average cost of producing 100 pounds of pork with Lot R was \$3.24 and with Lot Q was \$3.32.

On October 1st lot R was put on a ration of small sweet potatoes and strings which were fed raw and twice daily in the same manner as the grain ration had been given previously, and all other attention was just the same as before, and the same as given to Lot Q during the balance of the test. An examination of the Table shows that for October it required over five tons of the potatoes to produce 100 pounds of gain, which, if we assume the same influence prevailed in Lot R as existed in Lot Q, would give the potatoes a value of only about \$1.60 per ton. Of course this was with an exclusive potato ration and was with rather mature pigs, which should have been better adapted to such a highly carbonaceous ration than younger pigs. But these results showed the sweet potatoes not to be economical or desirable to be fed in this manner, which is a very common way to see them utilized by many farmers.

To test the value of the strings when fed in connection with other feeds and when fed even to younger animals, lot "V" was put on a ration of gluten meal, milk and sweet potatoes during November. The quantities eaten, gains made etc., are shown in Table 39, page 40. When these results obtained are compared with the check lot for these pigs, lot "U" as exhibited in table 38, we find that the 593 pounds of sweet potato strings eaten, in contributing to the 100 pounds of gain, has a value of \$2.40 or about 40 cents per hundred pounds of potatoes.

This shows that a combination of feeds supplementing one another so as to obtain a ration more nearly balanced in protein and carbohydrates will give much better results in the gains produced and the feeds consumed are economically used. Thus the sweet potatoes, when given by themselves were nearly worthless, but became valuable when fed with gluten meal and milk.

TABLE XXXVI.

*Results of Feeding Experiment with Lot S, showing Gains produced; Food Consumed. and Cost of same. 5 Pigs in the Lot.*

|  | Wt lbs | Gain lbs | FOOD EATEN Grain | FOOD EATEN Milk | FOOD REQ'D FOR 100 lbs GAIN Grain | FOOD REQ'D FOR 100 lbs GAIN Milk | COST OF 100 ....POUNDS GAIN.... Grain | COST OF 100 ....POUNDS GAIN.... Milk | COST OF 100 ....POUNDS GAIN.... Total |
|---|---|---|---|---|---|---|---|---|---|
| June | 261 | .... | .... | .... | .... | .... |  | ...... | ...... |
| July | 347 | 86 | 290 | 580 | 337 | 675 | 2 70 | 74 | 3 44 |
| August | 452 | 105 | 320 | 640 | 305 | 610 | 2 44 | 67 | 3 11 |
| Sept 1st, 15 days | 494 | 42 | 210 | 420 | 500 | 1000 | 4 00 | 1 10 | 5 10 |
| Sept. 2nd, 15 days | 500 | 6 | ? | ? | ... | .... | ...... | ...... | ...... |
| October | 532 | 32 | ? | ? | .... | .... | ...... | ...... | ...... |
| Average wt. of pigs at beginning | 52 2 |  |  |  |  |  |  |  |  |
| Average wt. of pigs at end | 106 4 |  |  |  |  |  |  |  |  |

## TEST OF THE VALUE OF COW PEA PASTURE FOR PIGS.

With the aim of getting at the value of Cow Peas as a pasture for pigs the old sheep pasture at the south-east portion of the farm, was planted to peas in June but the continued wet weather made the peas late in blooming and in maturing the peas in the pod. It was expected that the peas would be sufficiently matured to turn the pigs upon them by the first of August but they were not ready until September the first, and really not as far advanced as desirable until September the fifteenth. However, to compare the point of turning in upon them early and also later, lot "T" of five pigs were turned in upon the peas September 1st, and lot "S", fifteen days later. The check lots for these were lots "Q" and "R" which were kept in the pen. To test the use of younger pigs in such feeds, the pigs purchased on August 12th were divided into two lots, "U" and "V"; the former fed in the pen and the latter put on the pasture September 15th.

When entering upon the experiment it was hoped to run it for at least two months, but on October 1st there were so few peas left on the vines as to make it undesirable to continue the test after that date.

The pigs on pasture received no attention whatever except to see that they had an abundance of fresh water. The detail of the gains etc., are found in tables 36, 37, and 39. From these tables it will be seen that lot "T" made a gain of 31 pounds for September, against an average of 142 pounds for lots "Q" and "R", which would have a value of about $1.00. Lot "S" only made a gain of 6 pounds in 15 days. This would seem to indicate that the pigs turned upon the peas September 1st had the advantage. An examination and comparison of tables 38 and 39, shows that the younger pigs did much better on the peas than those of lots "S" and "T", and that the five pigs in lot "V" gained 49 pounds in fifteen days or over one-half (.65) pounds per day per pig. This, when all things are taken into consideration, is very satisfactory. The pigs in lots "V" compared very favorably with those in lot "U", as the gains would be 49 pounds as compared with 36 pounds if the gains of both halves of the month were assumed to be equal or if the pigs in lot "U" gained no more than those in lot "V" during the first 15 days of September, then the gains would stand 49 pounds to 52 pounds.

The results with the pigs on peas show them to be well adapted to the pigs which were about three months old when turned upon them. The results with the larger pigs show that pigs which have been highly fed and kept in a pen all their lives are not adapted to turning out where they will have to hustle for themselves if much gain is expected, nevertheless such pigs can maintain themselves and produce small gain. These experiments will be repeated another year with older pigs which have been acustomed to running out and which are not so fat when turned upon the peas.

The pasturing of the pigs upon the peas has a value to the farmer beyond what the pigs get and the gain they produce, in that they work the vines over, tread them down and distribute manure over the field. This puts the vines in a good condition to turn under and they decompose quickly which is particularly advantageous if the field should be desired to seed to wheat or rye. Again, the droppings from the pigs will introduce into the soil desirable ferments which would not be produced if the crop was simply turned under green.

### TABLE XXXVII.

*Result of Feeding Experiment with Lot T, Showing the gains Produced; Feed Consumed and Cost of same. (5 Pigs in the Lot.)*

| | Wt. ℔s | Gain ℔s | FOOD EATEN | | FOOD REQ'D FOR 100 ℔S GAIN | | COST OF 100 ....POUNDS GAIN.... | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain | Milk | Grain | Milk | Grain | Milk | Total |
| June | 233 | .... | .... | .... | .... | .... | ...... | ...... | ...... |
| July | 352 | 119 | 355 | 710 | 298 | 597 | $2.38 | $0 65 | $3.03 |
| August | 487 | 135 | 405 | 810 | 300 | 600 | 2.40 | .66 | 3.06 |
| September | 518 | 31 | ? | ? | .... | .... | ...... | ...... | ...... |
| October | 580 | 62 | ? | ? | .... | .... | ...... | ...... | ...... |
| Average weight of pigs at beginning | 46.6 | | | | | | | | |
| Average weight of pigs at end | 116. | | | | | | | | |

## TESTING THE VALUE OF JERUSALEM ARTICHOKE PASTURAGE FOR PIGS.

The same fifteen pigs which had been on the cow peas in September were transferred to a field of Artichoke during October, and allowed to feed on them at will by rooting them out of the ground themselves.

The Artichoke is a potato-like tuber which grows on the roots of a plant which much resembles sun flowers in appearance and belongs to the sun flower family. They have the following composition, and that of Potatoes is given for comparison.

| | Artichoke per cent. | Irish Potatoes per cent. | Sweet Potatoes per cent. |
|---|---|---|---|
| Water, | 78.7 | 78.0 | 71.8 |
| Ash, | 1.1 | .9 | 1.0 |
| Protein, | 2.5 | 2.2 | 1.5 |
| Crude Fibre, | 0.8 | 18.8 | 1.3 |
| Nitrogen Free Extract, | 16.7 | | 24.0 |
| Fat, | 0.2 | 0.1 | 0.4 |

### TABLE XXXVIII.

*Results of Feeding Experiment with Lot "U," Showing Gains Produced; Food Consumed, and Cost of Same. (5 Pigs in the Lot.)*

| | Wt lbs | Gain lbs | FOOD EATEN | | FOOD REQ'D FOR 100 ℔S GAIN | | COST OF 100 ....POUNDS GAIN.... | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain | Milk | Grain | Milk | Grain | Milk | Total |
| September 1st | 114 | .... | .... | .... | .... | .... | ...... | ... | ...... |
| September | 185 | 71 | 153 | 282 | 215 | 400 | $1 72 | $0 44 | $2 16 |
| October | 289 | 104 | 265 | 506 | 255 | 486 | 2 04 | 53 | 2 57 |
| November | 394 | 105 | 388 | 330 | 370 | 314 | 2 96 | 35 | 3 31 |

The results obtained show that Lot "S' gained about one-fifth of a pound per day per pig; lot "T" gained about two-fifths of a pound per day per pig, and Lot "V" gained about one-fourth of a pound per day per pig. While these are not large gains, yet when it is considered that the crop costs nothing to raise when once planted, (one planting lasting indefinitely) and that the land used is such as could not be used for other crops and that the pigs feed themselves, the gains produced have been economical. No doubt that a little slop or gluten meal or wheat bran, fed once a day, would have contributed, as with the sweet-potatoes, to a more economical use of the Artichoke and made pork rapidly and very cheaply.

### TABLE XXXIX.

*Results of Feeding Experiment with Lot "V"; showing Gain Produced, Food Consumed and Cost of Same.* (*5 Pigs in the Lot.*)

| | Wgt | Gain | FOOD EATEN | | FOOD REQ'D FOR 100 ℔s GAIN | | COST OF 100 ....POUNDS GAIN.... | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain | Milk | Grain | Milk | Grain | Milk | Total |
| September 1st | 115 | .... | .... | .... | .... | .... | .... | .... | .... |
| September 15th | 134 | 19 | 75 | 150 | 3.94 | 788 | 3.15 | .87 | 4.02 |
| September 30th | 183 | 49 | ? | ? | .... | .... | .... | .... | .... |
| October | 223 | 40 | ? | ? | .... | .... | .... | .... | .... |
| November | 342 | 119 | 70 | 330 | .60 | 277 | 0 60 | .30 | 3.31 |
| Sweet Potatoes | | | | 706 | .... | 593 | | | |

# SOME OF THE IMPORTANT RESULTS.

1. It was found that with some rations the gains on pigs could be produced as low as 2½ cents per pound.

2. In all the tests where properly compounded rations were used pork was produced at a profit when the pigs were not allowed to become too old.

3. The cost of producing a pound of pork increases with the age of a pig.

4. The aim should be to produce from 150 to 200 pound pigs at six to seven months old for the greatest profit.

5. Skim milk was found to have a feeding value for pigs equal to fully double the price charged at most of the creameries of the State.

6. Separator skim milk at ½ cent per gallon, and linseed and gluten meals at $15.00 per ton, have about the same value for balancing rations for pig feed.

7. Cream or "King" gluten meal was found to be more economical for balancing rations for pigs than linseed meal.

8. Ground fodder, such as the New Corn Product, was found to be a valuable addition to rations for pigs.

9. Sweet potato strings, cow pea pasture and Artichoke pasture, when properly used, produced pork economically..

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 64. JANUARY 1900.

# A STUDY OF THE CAUSE OF MOTTLED BUTTER.

By Chas. F. Doane, B. S., Dairy Bacteriologist and
Assistant Dairyman.

One of the most frequent questions asked the butter maker of this Station is for the cause of the uneven coloring often seen in butter. This peculiar spotted appearance is called "Mottles" by Dairymen in general and is characterized by one portion of the butter being much lighter colored than the other. The more deeply colored or highly colored portion appears to a superficial examiner to have absorbed more than a proportional share of the coloring matter while the light streaks seem to have an excess of butter-milk remaining in it as well as to have received too small a share of the coloring. This condition of the butter is not noticeable until the butter has stood a few hours after being worked.

The term "Mottled" can hardly apply to the small white specks often seen in butter and which are caused by small pieces of dry curd. These specks can be kept out by straining the cream just previous to churning through a hair sieve or perforated tin strainer. Mottles is a more deep seated trouble if we are to judge from the number of butter makers who have had difficulty in this way, and is usually supposed to be caused by some mismanagement, either in handling the cream or in the handling of the butter after churning. Those making butter on a small scale and especially during the months of May, June and July are the most likely to have mottled butter as they are not ordinarily supplied with the most improved machinery for handling the butter and the trouble is more likely to occur during these months as any unevenness in the coloring would be noticed only when the butter had enough natural color to distinguish clearly the different shades. Butter makers on a small scale seldom use artificial color. But the butter maker with eight or ten pounds to the churning is not the only one who is troubled with mottled butter, as a part of the butter coming from the larger and sometimes from the best creameries to the city commission men is mottled and that very distinctly. Sometimes the best butter makers have unevenly colored butter and more than one has been forced to give up a creamery on account of this trouble. Perhaps the next buttermaker who took charge would have no trouble whatever and this added to the general mystery surrounding the cause and the cure.

The cause of mottled butter has been and is yet a disputed question and a number of different theories have been advanced by writers and dairymen of more or less ability. The uneven distribution of salt has been given as the cause by much the larger number of modern writers, but many maintain that the use of excessively cold wash-water will cause mottles while the theory of the non-thorough washing of the butter has found a number of supporters. One writer of an old and at one time a standard work on dairying makes the statement that uneven pressure was a potent cause. Fleischman, the great German authority in dairy matters ascribes mottles to defects in the working and salting or in the temperature of working. Grotenfelt in his principles of modern dairy practice, translated by Woll of the Wisconsin Experiment Station says that mottled butter is sometimes caused by a species of bacteria which starting in small patches spread out through the mass giving a pale or faded appearance to the butter wherever the colonies reach.

The author, by practical experiments, has undertaken to sift these various theories to determine the cause or the most common causes of mottles as affecting the butter maker either in the creamery or the ordinary farm dairying. Experimental work was carried out along the line suggested by the theories advanced. The work was all done in the Station creamery where every modern appliance for the care of milk, cream and butter could be utilized. All of the milk used in these experiments was obtained from the Station herd and was secured as free from dirt and filth as practicable. This more than usual care makes the conditions considerably different from those met with in the ordinary creamery where milk comes from a number of sources and in varying conditions. At the same time however it made much more accurate work possible. The evening milk was allowed to stand in the refrigerator over night after being run over a Star cooler, it was then warmed and separated with the morning's milk. From the separator the cream went to the ripening vat, was cooled to 70 degrees fahrenheit and allowed to ripen until it showed .45 per cent. of acid when it was cooled to 50 degrees and was churned the next morning when there was from .55 to .60 per cent of acid. An ordinary box churn was used and the cream was churned at about 50 degrees. The butter was worked on a Mason worker which made six revolutions per minute and this part of the work was always done by the same person so that different lots of butter would receive the same amount of working for the time worked.

## THE EFFECT OF COLD WASH WATER.

Aside from the theory that the uneven distribution of the salt is the cause of uneven colored butter the theory held by the greatest number of butter-makers is that excessively cold wash-water or the free and injudicious use of ice in the churn is the cause of mottles. Different reasons why the cold wash-water should have this undesirable effect on the butter have been advanced. One is that the excessive cold effects only the outside of the granules, as fat is a poor conductor of heat, and the inside is not influenced by the cold. This is supposed to give a different shade to the two portions. Another reason given is that the cold prevents the salt from penetrating the granules because of the chilling of the outer portion.

To test the influence of the temperature of the wash-water the butter from each of five churnings was divided into two lots immediately after the butter-milk was drawn. One lot from each churning was washed with water at 52 degrees temperature, the temperature of churning. This is the temperature usually advised by authorities on butter making, and it certainly could have no evil effect as it would have no influence on the temperature of the butter granules. The other lot from each churning was washed with water from 35 to 40 degrees which will be found to be about the temperature of what is ordinarily termed ice-water.

It is obvious that the butter granules in an experiment of this kind must be larger than is usually advised or the light and more deeply colored portions of butter would be so small as to be unnoticeable. In this experiment the butter was churned until the granules were about three times the size of grains of wheat or about the size of peas. The granules run very unevenly in size and shape and will always be found to be the case in butter from cream churned at 50 degrees.

The cold wash-water was allowed to remain in the butter about one minute, which is about the average time in ordinary practice as it would take a minute for it to run from the churn if drawn immediately. But a few trials were made in which the water was allowed to remain in the churn until there could be no question but that the butter granules had been chilled throughout.

The result of these trials can be seen from the following table:

TABLE I.

| No. of churning | Temperature of wash water. | Time in wash water. | Time worked | Appearance after working. |
|---|---|---|---|---|
| 1st. | 50 | one min. | 3 min. | Evenly colored. |
| 1st. | 50 | " | 4 min. | Evenly colored |
| 1st. | 35 | " | 3 min. | Slightly mottled. |
| 1st. | 35 | " | 4 min | Evenly colored. |
| 2nd. | 50 | " | 3 min. | Slightly mottled. |
| 2nd. | 50 | " | 4 min. | Evenly colored. |
| 2nd. | 35 | " | 3 min. | Slightly mottled. |
| 2nd. | 35 | " | 4 min. | Evenly colored. |
| 3rd. | 50 | " | 3 min. | Evenly colored |
| 3rd | 50 | " | 4 min. | Evenly colored |
| 3rd. | 40 | " | 3 min | Slightly mottled. |
| 3rd | 40 | " | 4 min. | Evenly colored. |
| 4th | 50 | " | 3 min | Slightly mottled. |
| 4th. | 50 | " | 4 min. | Evenly colored |
| 4th. | 40 | " | 3 min | Distinctly mottled |
| 4th. | 40 | " | 4 min. | Evenly colored |
| 5th. | 50 | " | 3 min. | Evenly colored. |
| 5th. | 50 | " | 4 min. | Evenly colored. |
| 5th. | 40 | " | 3 min. | Evenly colored. |
| 5th. | 40 | " | 4 min. | Evenly colored. |
| 6th. | | | | |
| 6th. | 40 | 15 | 3 min. | Slightly mottled. |
| 6th. | 40 | " | 4 min. | Evenly colored. |
| 7th. | 40 | " | 3 min. | Evenly colored |
| 7th. | 40 | " | 4 min. | Evenly colored |
| 8th. | 40 | " | 3 min. | Slightly mottled. |
| 8th. | 40 | " | 4 min. | Evenly colored. |
| 9th. | 40 | " | 3 min. | Evenly colored. |
| 9th. | 40 | " | 4 min. | Evenly colored. |

It will be seen from table No. 1 that out of the five lots of butter washed with water at 50 degrees for one minute and worked three minutes, but one lot was mottled and that very indistinctly so. Out of five lots washed with excessively cold water for one minute and worked three minutes, four were mottled, one of them being very distinctly so. Not any of the butter worked four minutes was mottled. Out of the butter washed with the cold water for fifteen minutes and worked three minutes, two lots were slightly mottled. None of the same butter was mottled when worked four minutes. In every case of uneven coloring excepting the one where the streaks were the most distinct the trouble appeared to have come from the individual grains as the spots were round and very small. However it was found, after a number of trials, that any butter which is badly mottled if put on the worker and worked just the right length of time will have the same characteristic appearance as the mottled butter resulting from experiments noted in Table No. 1. The butter looks streaked rather than otherwise at first. As the working progresses and the butter is turned ovor and over the large streaks naturally become smaller and also become rounded in form, until just on the border land between mottled and perfectly colored butter the spots are very small, appear to be round and are rather indistinct. The reason why butter washed with excessively cold water is more likely to be mottled can be explained on more satisfactory grounds than is usually advanced. Butter so washed is of course much harder than when washed with water at 50 degrees. When it is put on the worker it will be found to be much more difficult to handle. And it will often require three or four revolutions of the worker before the granules become firmly enough matted together to allow being turned with a ladle. Even after this stage is reached the butter is so hard and so difficult to turn with the ladle that it is almost impossible to give it the same amount of working with the same number of revolutions of the worker that the softer butter would receive. The difference in the working of the soft and hard butter was very noticeable even where the amount of butter was limited and where a small worker was used as was the case at this Station during these experiments. In a large creamery where the butter from 2000 pounds of milk would be put on the worker at one time the difference would be much greater. It is very easy to conceive under these conditions how a butter-maker, who had been in the habit of washing the butter in water at the temperature of churning and suddenly changed to colder water, would have mottled butter. The mottles would resemble small round pellets and the butter-maker would naturally conclude that the action of the excessively cold water on the separate granules was the cause of his trouble. He would fail to consider that the butter had not received sufficient working because it was harder than the butter which he had been in the habit of handling.

With a combined churn and worker, such as is coming into general use in many of the larger creameries, the difference in the length of time required to work soft and hard butter is greater than with the Mason worker. The rollers in the combined churn are so far apart that when the butter is washed with water as low as 35 degrees it will require several minutes of working before the granules will be formed into a compact mass and the actual working can begin.

The butter which was allowed to remain in the cold water for fifteen minutes behaved practically the same as where it was allowed to remain for only one minute. It could not even be noticed that it was any harder, which would go to show that even with one minute washing the granules must have been chilled through.

It is well to call attention to the fact that though many of the lots were mottled when worked three minutes none were mottled after working four minutes. This fact would seem to suggest that it is possible, in some cases at least, to work the mottles out of butter. Attention will be called to this again.

## EXPERIMENTS WITH SALTING.

As has been mentioned before the theory for the cause of mottled butter which has found the greater number of supporters is that having the salt unevenly distributed through out the mass of the butter will cause it to be unevenly colored. To test this theory the butter from each of twenty churnings was divided into two lots after washing. One lot from each churning was worked one minute without salting, and set in the refrigerator. The other lot from each churning was salted, worked one minute and then set in the refrigerator. Not one of the unsalted lots was at all mottled while in every case the salted lots were very distinctly mottled. Furthermore by simply tasting the light and more deeply colored portions of the butter it could be easily distinguished that the former had very little, if any, salt and the latter had enough and to spare. So marked was this difference in the taste that no chemical analysis was necessary to demonstrate that one portion had much more salt than the other. Since performing these experiments the author has had access to a large number of samples of butter which have been marked down in price by commission men because of being mottled. In every case where the unevenness in the coloring was very distinct it was entirely possible to distinguish by the taste that the light streaks either had no salt or less salt than the more deeply colored portions. So many samples of mottled butter have been examined and the experiments at this Station were so marked and uniform in their results that it does not leave much room for doubt that considerable, if not the greater part of the uneven colored butter, is so because the salt has not been thoroughly worked in.

It was noted in the experiments where a part of the butter was salted and a part was worked without salt that the latter was always much lighter in color than the former after the salted lots had received the necessary amount of working to evenly distribute the salt and make it even in color. To demonstrate this point with butter which had been treated the same in every way except in the salting, each of five churnings of butter was divided into two lots. One lot from each churning was worked twenty revolutions of the worker without being salted. The other lots were salted and worked the same number of revolutions, which was sufficient to thoroughly distribute the salt. One pound prints were made from each of the churnings, half of the pound being of unsalted and the other half of salted butter. The difference in coloring could be distinguished slightly immediately after working and printing. At the end of twenty-four hours this difference was very marked. These prints of salted and unsalted butter were in reality mottled butter, as the difference in the shade of the coloring of the two portions came from the same cause as the patches or streaks of light and dark seen in tubs of mottled butter.

## HOW THE SALT CAUSES MOTTLES.

Having the salt unevenly distributed through the butter causes it to be unevenly colored is certain in many cases. It is also certain that it does this by giving the salted portion a more pronounced yellow color. Why the salt has this effect has not been satisfactorily explained. It has been suggested that it is because the salt drives out the butter-milk along with the excess of water in the butter, and the fact that the unsalted portions of the butter appear to have an excess of butter-milk would suggest that this might possibly be a good explanation. To test this the samples of butter before alluded to where one lot from each of five churnings was salted and the other lot from the same churning was unsalted were submitted to a chemical analysis to determine the per cent. of curd.

The following table shows the result of the analysis:

TABLE II.

| Lot. | Casein per cent. |
|---|---|
| a1 | .33 |
| a2 | .32 |
| b1 | .24 |
| b2 | .23 |
| c1 | .26 |
| c2 | .39 |
| d1 | .59 |
| d2 | .34 |
| e1 | .46 |
| e2 | 1.8 |

In the table where the two lots are given as a1 and a2 the same letter represents the same churning. All of the numbers 1 were unsalted and the numbers 2 were salted. Thus a1 and a2 are two lots from the same churning; a1 was unsalted and a2 was salted.

From three of the churnings the salted lots had less Casein than the unsalted. In the case of d1 and d2 the difference was very marked. In the other two churnings, however, the salted lots had more Casein than the unsalted. In all of these churnings the unsalted lots were much lighter in color than the salted. In the churnings where a larger percentage of Casein was found in the salted than the unsalted the difference in the shades of color was just as marked as where the larger percentage of Casein was found in the unsalted lots. It is evident this being the case, that mottles is not caused by any excess of Casein in the unsalted portions.

To test farther the result of an excess of butter-milk in the butter, each of ten churnings of butter were divided into two lots. One lot from each churning was salted and worked without being washed. The other lots were washed with water at 48 degrees until not a trace of butter-milk could be detected in the water as it flowed from the churn. The wash-water was used colder than normal to keep the granules from uniting during the working and thus holding the butter-milk. All of these lots were worked one minute and were then set in the refrigerator for twenty-four hours. At the end of this time all lots were found to be very unevenly colored, the unwashed lots as badly so as the washed lots as far as the eye could detect. It must be admitted, however, that the light streaks in the unwashed butter were a little lighter in color than in the washed butter. But the evidence of the chemical analysis must be deemed conclusive, and as from two churnings the unsalted butter according to the analysis did not contain as much Casein as the salted lots from the same churnings, and the unsalted lots were lighter in color than the salted. Therefore it is fairly evident that a relative excess of Casein was not the cause of the lighter color and is not the cause of the light streaks in mottled butter.

The author believes that the reason why salted butter has a deeper or yellower color is because the salt has some physical action upon the fat in the butter. Salted butter admits more light than unsalted. This can be seen by cutting a thin slice of badly mottled butter and holding it between the eyes and a window or a lighted lamp. The salted and yellower portions are seen to be translucent. They allow considerable light to pass through, while the lighter and unsalted portions were opaque. This was demonstrated to the best advantage by cutting a thin slice of the prints where one half of the print was of unsalted butter and the other of salted butter. The unsalted portions allowed no light whatever to pass through while the salted part was distinctly translucent. Why or how the salt has this effect has not as yet been explained. Samples of butter were submitted to different physicists for an explanation, but they could offer none. There is a theory that fat, under certain conditions, has a varying tendency to crystalize. If this be so perhaps the salt would aid in this crystallization. This if one, would be a good explanation of the point in question.

## HOW TO PREVENT MOTTLES.

As the uneven distribution of the salt in the butter is the cause of mottles, then obviously the way to prevent the trouble is to get the salt thoroughly worked in. But in doing this butter makers have experienced considerable difficulty, which is often more imaginary than real. Many butter makers who understand the cause of mottles still have difficulty because they are afraid of over working. That there is danger in over-working in some cases has been verified too many times to admit of dispute. But it is doubtful if there are many instances where the butter would need to be over-worked to thoroughly incorporate the salt. The tendency is to under-work instead of to over-work butter. Butter makers desire a coarse grain whereas a fine grain which would come with more working would be more acceptable.

Working the butter is the only way to insure its being evenly colored and how to work it sufficiently in all cases and not injure the grain, is the question. It is often advised to give the butter two workings, working it only sufficiently the first time to incorporate the salt so that it will be dissolved. The second time the butter is put on the worker after it has stood in the refrigerator for twenty-four hours it can be worked without as much injury to the grain as when it was fresh. This is the claim made by advocates of this system.

To test the result of working butter under different conditions all the butter from one churning was washed with water at 50 degrees and was given the required amount of working from 20 to 24 revolutions of the worker to insure the salt being so thoroughly distributed that the butter would be evenly colored. The next churning was washed with water from 38 to 40 degrees and worked from 21 to 24 revolutions of the worker. The third churning was washed with water at 45 degrees, worked ten revolutions of the worker and set in the refrigerator at 50 degrees for 24 hours, when it was worked from 11 to 14 revolutions in addition to the 10 revolutions of the first working. The fourth churning was taken immediately after washing and was set in the refrigerator without working, where it was allowed to remain for 24 hours. At the end of this time it was worked from 21 to 24 revolutions of the worker. This series was repeated five times in all being twenty churnings. Samples of this butter were submitted to Major Henry E. Alvord, Chief of the Dairy Division of the Department of Agriculture, who kindly agreed to score the grain. It was found on inspection that the samples from the lots washed with water at 40 degrees and below and worked 21 revolutions were slightly mottled thought Mr. Alvord gave the assurance that they were not sufficiently so to lessen the market value. The same butter worked 24 revolutions of the worker was colored perfectly.

As nothing but the grain of the butter was to be scored, a basis of 100 per cent. for perfect was used instead of the smaller basis given in ordinary scoring when all qualities are to be taken into consideration. It would be very easy however, to calculate the score given on the basis in common use.

The scores on three of the series is given in the following table:

### TABLE III.

| Sample. | Temperature of water | Revolutions of worker, 1st working. | Revolutions of worker, 2nd working. | Score. |
|---|---|---|---|---|
| 1 | 50 | 21 | ... | 98 |
| 2 | 50 | 24 | ... | 100 |
| 3 | 40 | 21 | ... | 100 |
| 4 | 40 | 24 | ... | 99 |
| 5 | 45 | 10 | 11 | 98 |
| 6 | 45 | 10 | 14 | 99 |
| 7 | 45 | ... | 21 | 98 |
| 8 | 45 | | 24 | 96 |
| 9 | 50 | 21 | ... | 99 |
| 10 | 50 | 24 | ... | 98 |
| 11 | 38 | 21 | ... | 100 |
| 12 | 38 | 24 | ... | 100 |
| 13 | 45 | 10 | 11 | 98 |
| 14 | 45 | 10 | 14 | 98 |
| 15 | 45 | ... | 21 | 97 |
| 16 | 45 | ... | 24 | 95 |
| 17 | 50 | 21 | ... | 98 |
| 18 | 50 | 24 | ... | 99 |
| | | | ... | |
| 19 | 40 | 21 | ... | 100 |
| 20 | 40 | 24 | .. | 99 |
| 21 | 45 | 10 | 11 | 98 |
| 22 | 45 | 10 | 14 | 97 |
| 23 | 45 | ... | 21 | 96 |
| 24 | 45 | | 24 | 95 |

In table III sample Nos. 1 and 2 came from the same churning as did three and four from the second churning and so on through the table, two samples coming from each churning. Only three series are given as the other two series were practically the same as the ones given, and would not change the general result.

A study of the table will show that the butter washed with water at 40 degrees and under, and worked 21 and 24 revolutions of the worker immediately after being taken from the churn has a slight advantage in regard to the average grain while the butter set in the refrigerator for 24 hours without any working whatever has considerably the lowest average grain. There is practically no difference in the average grain of the lots washed with water at 50 degrees and given all the working immediately after being taken from the churn and the lots washed with water at 45 degrees and set in the refrigerator for 24 hours after being partially worked. It will be remembered that this last method of partially working the butter and allowing it to harden in the refrigerator before the final working is the one usually advised by the best butter-makers to be followed in cases where there is serious trouble with mottles.

Mr. Alvord in his notes given along with the score of this butter, said that it was very doubtful if, except in a few cases, of the lowest score any of the butter would have been given other than a perfect score on grain in a contest such as is held by State Dairy Associations. The objection of Mr. Alvord to the butter scored the lowest and which the table shows were the lots which had been set in the refrigerator previous to receiving any working whatever was that it was very dry and sticky. This was noticed in working the butter. So much so that considerable difficulty was experienced by the butter adhering to the worker. This was the case with all the lots set in the refrigerator before working and it will be noticed from the table that the longer the butter was worked the more pronounced was this objectionable feature. The butter which handled the nicest on the worker, which scored the highest and which seemed to impress Mr. Alvord more favorably than any of the other because, as he said, of the fineness and compactness of the grain was that which came from the lots which were washed with water at 40 degrees and below. The only point that could be urged against this method is that it requires slightly more working to insure evenness of coloring and is a little harder to handle with the ladel while working. During the hot weather of summer it would certainly be much preferable as the working can be finished before the butter has become so soft through contact with the warm air as to render working difficult if not impossible.

## EFFECT OF ICE-WATER ON SOLIDITY OF BUTTER.

There has been an objection urged by many butter makers against the use of cold wash-water or the use of extreme cold in any way connected with butter making. It is claimed that where ice water is used to wash the butter or that where ice is added to the cream during churning, the butter so treated will not "Stand up" so well comparatively under the effect of a warm temperature. In other words it would become softer or would become soft quicker when exposed to summer heat. This would certainly be a very serious objection if it were so.

Though any work along the line of testing the effects of ice and ice-water on the consistency of butter was outside of the work undertaken and which this bulletin is supposed to cover, it was deemed best to experiment along this line before advising the use of such cold water in washing butter.

To test the effect of ice-water on the butter each of ten churnings was divided into two lots immediately after the butter-milk had been drawn. One lot from each churning was washed with water at the churning temperature, from 50 to 52 degrees. The other lot was washed with water at from 35 to 40 degrees. One sample of butter from each lot was placed at a temperature of 70 degrees and another samply from each lot was placed at a temperature of 48 degrees. After standing for a day all samples were placed at a temperature of 60 degrees and allowed to stand for 4 hours, so that all samples would be the same temperature throughout. At the end of the 4 hours the temperature was gradually increased to 80 degrees. The samples were watched during this time to see which became soft the quicker and which was the softest at the end of the time. As there has been no mechanical method for determining exactly the comparative solidity of different lots of butter we were forced to rely solely on the sight and touch. This is not exact of course, but as far as all practical purposes are concerned there would be no difference in the market value of two lots of butter other things being equal where the difference in firmness could not be easily distinguished by pressure or cutting. In the work at this Station all lots of butter were found to be practically the same in consistency. Some times the lot washed with the colder water and set in the refrigerator would be found to be a little harder than the other and vice versa. In no case was the difference sufficiently marked to be used as a basis for any conclusions or even suspect that one method was superior to the other. It was noticed, however, that samples of the butter whether washed with the water at 50 degrees or 35 degrees, if put in the refrigerator retained its firmness when exposed to summer heat a little better than that which had been kept at a warmer temperature. Though after all lots had been held at 80 degrees for two hours no difference in consistency could be distinguished. Whether this firmness of the samples which had been kept in the refrigerator was due to the treatment at the time of churning and washing or because insufficient time was allowed for all the butter to get to 60 degrees while it was being held at this temperature is questionable.

As was stated at the beginning of this Bulletin one of the most frequent questions asked at this Station was concerning the cause of unevenly colored butter. The great majority of questioners are dairy farmers who own a few cows and make their own butter. The great need on the small dairy farm is better facilities, more tools to work with. It is because of the lack of what are almost necessities for handling the product that so much difficulty is experienced in making butter that commands the best market price. The principal reason why the small dairyman has so much unevenly colored butter is because he has no tools with which the butter can be properly worked. The old-fashioned butter bowl and ladle are still in univorsal use on the smaller dairy farm. Where but three or four pounds of butter are made at one time for the family use the butter bowl may be sufficient but where more than this is made and made to sell it is impracticable if not impossible to work the salt in evenly without some more advanced way of handling the product. A number of small inexpensive machines for working butter are sold by different firms who handle dairy apparatus. Any one of these is superior to the hollow bowl and spoon.shaped ladel.

## CONCLUSIONS.

1. The uneven distribution of salt is the cause of unevenly colored butter spoken of as mottled butter.

2. Washing the butter with water below 40 degrees does not cause mottles. It does, however, make a little more working necessary to thoroughly distribute the salt.

3. The light colored streaks or portions of mottled butter are not caused by an excess of casein, but mottles is evidently caused by some physical action of salt on the butter fat which causes it to admit more light.

4. Mottles can be prevented by working the butter sufficiently to thoroughly distribute the salt.

5. Butter washed with water at 40 degrees and under and worked immediately shows a better grain when sufficiently worked to insure its being evenly colored than with any other treatment.

6. Washing butter with water at 40 degrees and under does not injure its firmness when subjected to high temperature.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 65. MARCH 1900.

# SOME IMPORTANT INSECTICIDES, FUNGICIDES AND APPARATUS FOR THEIR APPLICATION.

BY W. G. JOHNSON, C. O. TOWNSEND AND H. P. GOULD.

## GENERAL INTRODUCTION.

In the preparation of this bulletin the authors have endeavored to answer the more important questions that are asked eash season about insects and fungi, insecticides and fungicides and the apparatus now generally used for their application. A spray calendar (see page 85) especially adapted to this state, is also appended, with a hope that it will serve as a guide to the fruit grower and trucker.

At the present time, spraying is an important part of successful fruit growing. The regular and systematic application of insecticides and fungicides is one of the most valuable and profitable pieces of work done on the farm. The spray pump, properly used, is worth as much to the grower of fruits and vegetables, as the policy covering the insurance on his house or barn. In fact, you must "insure" your crops from destructive insects and fungi, by practicing modern methods of spraying. There has been a decided awakening to the truthfulness of the above statement in the past few years, and thousands of growers are now spraying and seeking information, where only a short time ago they were counted by hundreds.

The authors will cheerfully answer any inquiry along their respective lines not clearly explained in the following pages.

This bulletin is published out of the funds appropriated for the State Horticultural Department, being the third of this series, and is distributed by the Experiment Station in accordance with the Laws of Maryland 1898, Chapter 189.

# SOME IMPORTANT INSECTS AND INSECTICIDES.

By Willis G. Johnson.

*Introductory.*—In order that our readers may understand why one remedy is used for one insect and not for another it will be necessary for us to make some brief references to the structure and habits of certain types. For example, the great mass of injury to plants by insects falls under two heads; first. where the plant itself has been eaten, and second, where the juices have been sucked out leaving the tissues.

*Biting Insects.*—Insects causing injury of the first class are called biting or chewing insects, familiar examples of which are the beetles, grasshoppers and caterpillars, such as the cabbage worm, army worm, etc. They have well developed jaws fitted for cutting and chewing the plant. Such insects can be destroyed by use of direct poisons, such as the arsenicals. Where applied to the leaves or other parts of the plant it is eaten by the insect, causing its death.

*Sucking Insects.*—On the other hand. the second type have long lance-like beaks fitted for sucking. This class includes the scale insects, plant lice, squash bug, harlequin or terrapin bug, etc. They obtain their food supply by inserting their beaks into the tissues of the plant, sucking the juices from within. The external application of arsenical poisons to plants would have little if any effect upon this group of insects, as the poisons do not enter into the cells of the plants. It is necessary, therefore, to employ some other substances for their destruction. To this end materials are used which will act externally on the bodies of the insects, either as a caustic or to smother or stifle them by closing their breathing organs. I might say in this place that insects do not breath through their mouths as do higher animals, but through small openings on either side of the body called spiracles. By spraying anything of a caustic or oily nature over the body of an insect these spiracles are closed and the creature is destroyed. Sometimes the fumes of poisonous gases are employed to suffocate insects, as will be described later on. Insects are sometimes repelled by obnoxious substances.

The above remarks apply especially to insects which feed upon the exterior of plants or pass the greater portion of their lives in an exposed condition, where they can be readily reached by one of the methods mentioned. Certain other insects, of both classes, biting and sucking, are subterranean in their habits, that is, they feed and live upon the roots of plants below the surface of the ground. Among these the white grub, and root lice are common examples. Still other insects live in stored grain, seeds and the manufactured products of the mill, and even the mill itself. Here again the arsenics and irritants cannot be used and we must resort to various fumes and gases.

## WHAT ARE THE EXTERNAL POISONS FOR BITING INSECTS?

For the destruction of insects coming under the general head of biting insects the arsenical compounds have practically supplanted all others*. Those in most common use are Paris green and London purple. Still other compounds are coming into general use, among which we recommend arsenate of lead and green arsenoid. We do not advise, under any circumstances, the use of pure white arsenic.

*Paris Green.*—This is a green, rather coarse powder, and is composed of arsenic, copper and acetic acid (known as aceto-arsenite of copper). It does not remain in suspension long in water and this is its chief fault. It can be purchased at 16 to 20 cents per pound, the price varying with the amount bought. There are some adulterated grades upon the market sold for a less price, but these should be avoided. In some cases these low grades are sold for the best. Last July we found one of these adulterated compounds on the Eastern Shore of Maryland and had the director of the Experiment Station make a chemical analysis of it. It contained only 31.6 per cent. of arsenous acid; where, theoretically, it should have contained 58.6 per cent. For commercial purposes Paris green is considered pure when it contains not less than 50 per cent of arsenous acid. If you have reason to suspect that the material you are using is not what it should be, send a sample to the Experiment Station, giving such facts as you can, as to who manufactured or sold it.

*London Purple.*—This is a waste product obtained in the manufacture of analine dyes, and its composition is, therefore, not the same in all cases. There are several chemicals in this compound, chief among which are arsenic and lime. A greater per cent of the arsenic is soluble in Paris green, and consequently, there is more danger of injuring the foliage when London purple is used. It is a very fine, purplish powder and kept in suspension in water more easily than Paris green. It costs less than Paris green, the price being from 12 to 16 cents per pound. As a rule London purple is not so generally adulterated as the Paris green.

*Arsenate of Lead.*—This is a comparatively new insecticide, is white in general color, and when sprayed upon foliage may be distinguished at a glance. There is not much danger of burning the foliage with this material and it adheres more readily than Paris green or London purple. It is composed of arsenate of soda and acetate of lead. It costs a little less than the Paris green. It remains well in suspension, and the fact that it is harmless to foliage makes it a valuable substance. It is now manufactured and placed on the market at 15 to 18 cents per pound. It forms almost a pure white precipitate of pasty consistency.

*Green Arsenoid.*—This material is a substitute for Paris green and is applied in the same manner. It is more bulky than Paris green and contains no acetic acid; and is not, therefore, so apt to burn foliage. It can be used in solution or dry. It has been tested thoroughly by several Experiment Stations and has the decided advantage over Paris green (1) in costing less, 13 to 15 cents per pound, and (2) in being a very fine pulverant powder, which remains easily in suspension when in water.

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*Hellebore is generally used as a remedy against certain biting insects, but as it is not an arsenical compound it has not been included under this head, and is listed with the powders on page 62.

## HOW ARE THESE POISONS APPLIED?

The arsenical compounds are applied in three different ways, namely: (1) wet, (2) dry, and (3) poison baits. The first method is most commonly used and is best adapted for the protection of orchards, shade trees, etc. The dry method is used extensively in the south for combatting the cotton worm and is feasible on low growing crops, such as potatoes, cabbage, etc. The third method is used for destroying cut worms, wire worms, etc.

*The wet method.*—Either Paris green or London purple may be used in water, for general purposes, at the rate of one pound to 160 gallons of water, or one ounce to 10 gallons. First put the poison in some small vessel, add a little water and stir until a thick paste is formed, then slake an equal quantity of good stone lime and stir this into the poison. The lime lessons the danger of burning the foliage by taking up the free arsenic. Twice the quantity of lime will do no injury. The lime is especially desirable where the delicate foliage of peach and plum is sprayed. After the poison and lime have been prepared they should be stirred in the proper amount of water. The arsenate of lead is used without lime.

It is now a very common practice to use the same amount of poison in Bordeaux mixture instead of using water; thus spraying for both insect pests and fungous diseases at the same time. Usually four ounces (¼ pound) of poison in a barrel (40 gallons) of Bordeaux is recommended. For method of preparing Bordeaux mixture see page 67.

*The Dry Method.*—Very often it is desirable to use Paris green dry. It should then be mixed thoroughly with land plaster, air slaked lime or common wheat flour. For general purposes one pound of poison to 100 pounds of diluting material is used. When only small quantities are needed, mix one-ounce of poison with six pounds of either lime, plaster or flour. If used on low growing plants, the mixture can be placed in an old fertilizer bag and distributed evenly by merely shaking the bag. This should be done early in the morning when the dew is on or immediately after a rain. In small garden patches, an old vessel with perforations in the bottom can be used as a "shaker".

There is also upon the market an apparatus especially devised for the dry application of this poison. One of these dry powder guns is shown in the illustration, Figure 29, page 83. Larger patented air-blast machines are frequently used in the south in cotton fields. The "bag and mule" method is, however, most commonly used. On tobacco, the dry method is very satisfactory, using land plaster about 100 pound for every pound of Paris green.

*The Poison Bait.*—Where it is not desirable to place the poison directly upon the plant, the poison bait can be used to good advantage. It is a well known fact that cut-worms, wire-worns, grasshoppers, etc., have a liking for sweetish substances. We know also that these creatures eat bran with a relish. By combining the bran with molasses, or syrup made from sugar we have an ideal bait, and the worms will eat it in preference to anything else when it is available. By poisoning this material with Paris green we have a good remedy, cheap and easy to apply. The ingredients used for making the poison bait are as follows:

| | |
|---|---|
| Wheat bran | 50 pounds. |
| Molasses, (any kind) | 2 quarts. |
| Paris green, (good grade) | 1 pound. |
| Water | (Enough to make a thick mash) |

The bran should be placed in an old tub or barrel, and to this the Paris green should be added and stirred thoroughly with a shovel or other implement before the water or molasses is poured in. Stir the molasses with about a gallon of warm water and pour it over the bran and Paris green, thoroughly stirring until it is well mixed. Then add enough water to make a mash, about the consistency of dough, so that it can be handled easily without running. The materials having been prepared, it is now applied to land to be planted in tobacco, tomatoes, cabbage or other crops, and to do this successfully, several essentials are necessary.

1. Land, if sod or grass, should be prepared several days in advance.

2. After the drills are made a pinch of poison mash, about as much as one could hold on a table spoon, should be dropped in the vicinity, (not in the exact place) of the spot where the plant will be set. This should be done before the plants are set out.

3. The application should be made in the afternoon, as near evening as practicable; but where it is necessary, in order to get over large areas, there is no objection to dropping it any time during the day.

4. Care should be taken to keep chickens, turkeys, or animals of any kind that would be liable to eat the mash, out of the field for a day or two, or until after the plants are set.

One of our correspondents who used this method on his tobacco land said: "The cut worms came up readily, ate it and were killed before the tobacco was planted." He said five or six dead worms were often found to a hill.

### WHEN IS THE TIME TO SPRAY WITH ARSENICALS?

As a general rule, the first spraying is made, for the destruction of codling moth (or apple worm) of the apple or pear, immediately after the falling of the blossoms. The second spraying should be made a week to twelve days later, just before the fruit turns down on the stem. These two sprayings are the important ones, so far as the codling moth is concerned. If the spraying has been properly done there will be a film of poison solution over the calyx or eye end of the apple, and when the worm endeavors to enter, and it most always goes to the calyx end, it gets its poisonous dose and is destroyed. If the spraying is delayed until after the apple or pear turns downward, then it is too late, as very little good can be expected so far as wormy fruit is concerned.

For leaf eating insects the spray should be applied when the first creatures are discerned. In case of the potato, tomato, cabbage, sweet potato, and other low growing crops, it is not best to wait until the pests appear; but spray early and often to keep them from multiplying. The destruction of the early brood means thousands later in the season. Never spray your trees when they are in blossom, on account of destroying honey bees and other useful insects. The bee is useful in that it fertilizes the fruit.

*Caution.*—In using any of the arsenical compounds, whatever manner you apply them, bear in mind they are poisonous, and should be so labeled. If used as directed above, there is absolutely no danger attending their application. The poison disappears from any plants upon which it is sprayed within 20 to 25 days; and even if the plants were eaten immediately after the spraying, there would be no danger of poisoning. To illustrate in the case of the apple, it has been estimated that a person would have to eat several barrels at a time to get a poisonous dose; and with cabbage, dusted as recommended, about twenty-five large heads, at one meal, might prove dangerous if eaten by one person; but even in this event death would not result from poisoning.

In all your work never use more poison than is recommended. Follow directions as closely as possible. The philosophy of the old colored man, who reasoned that if a quarter of a pound of Paris green in 40 gallons of water, would kill the bugs on his cabbage "dead", a half a pound ought to "kill them deader", should not be followed for fear of killing the plants also.

## WHAT ARE THE MATERIALS FOR DESTROYING SUCKING INSECTS?

The remedies for the destruction of sucking insects are simple,but need the same care in their preparation and application that attend the arsenicals. The standard materials used for sucking insects are: (1) soap, (2) kerosene, (3) crude petroleum, (4) tobacco, (5) insect powder, (6) sulfur,* (7) bisulfid of carbon, (8) hydrocyanic acid gas, etc. We will briefly discuss each of these substances.

*Soap Solutions.*—Any good soap is effective for the destruction of soft bodied insects; but those made of fish oil, commonly sold under the name of whale oil soaps, are most generally used, and are best adapted for spraying. There are several brands and grades of whale oil soaps upon the market, selling from 3 to 5cts per pound, the price depending on the quantity purchased We have found the soap made with caustic potash very much better than those made with caustic soda. In ordering the soap, insist upon having a good grade made with caustic potash.

For plant lice and delicate larvae, such as the pear slug, dissolve one half pound of soap in a gallon of water and spray thoroughly. Any ordinary soft soap, made upon the farm, can be utilized, but double the amount should be used.

As a winter wash, the whale oil soap has no superior, as a remedy against the San Jose scale and other scale insects. It should be applied in the fall, winter or early spring, while the trees are dormant, using 1¾ to 2 pounds to a gallon of water. It should be put on with a good sprayer, and while hot. Where a large number of trees are to be sprayed, the soap should be dissolved in large iron vessels, and thoroughly strained before being placed in the sprayer.

*Kerosene Solutions.*—Kerosene emulsion has long been an effective remedy for certain insects; but not until recently has an apparatus been designed for mechanically mixing oil and water, thus doing away with the old method of making the emulsion. We have found these combination kerosene sprayers very satisfactory, and have used and tested the bucket, knapsack and barrel types. For an account of this apparatus see page . The water is placed in one tank, the kerosene in another and by setting a gauge, the desired percentage is obtained. If you already have a sprayer of the old type, you can make the emuslion according to the following directions.

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*The spelling of various chemical terms used in this bulletin is in accordance with the Standard Dictionary and is now generally adopted. Thus sulphur is now spelled sulfur.

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| Hard (or soft) soap (ivory soap preferable) | One half pound. |
| Water (rain water if convenient) | One gallon |
| Kerosene (common coal oil) | Two gallons. |

Put the water in a vessel holding four or five gallons, add the soap by shaving into thin pieces, place on a stove and bring to the boiling point, occasionally stirring it to dissolve the soap; then remove to the yard, or some convenient place away from the fire, and pour the kerosene directly into the water. This should then be pumped in and out of the vessel with a good force pump for from 5 to 10 minutes, or until the emulsion is formed. If properly made, it will have the appearance of buttermilk, and will readily mix with water without any oil coming to the surface. It will keep an indefinite length of time, becoming a semi-solid compound when cold. If used when fresh it can be diluted with cold water to the strength desired; but if cold and hard, warm water should be used. For plant lice every gallon of the emulsion should be diluted with from 10 to 12 gallons of water, and applied with a good spray pump.

Under no circumstances do we recommend the use of pure kerosene upon plant life of any kind. This material has been used, undiluted, by some persons, without any apparent injury to the tree; but there are so many uncertainties attending its use, we do not consider it safe and do not recommend it.

*Tobacco.*—Tobacco may be used as an insecticide (1) in powered form, (2) in solution, or (3) burned. Finely ground tobacco known commercially as tobacco dust is a powerful insecticide. It is often used around trees affected with root-lice. Two or three inches of the surface earth is taken away from around the trees and about 1½ to 2 pounds of tobacco dust evenly scattered over the surface and afterward covered with dirt. The first application should be made in June, and if necessary repeated in August. This remedy is very effective against the black root Aphis of the peach and the woolly Aphis of the apple. The dust shaken over plants infested with delicate larvae and plant lice is also destructive to insect life.

In making a decoction cut up the old stems and leaves, add water and boil down until a strong solution is obtained. It can be sprayed directly upon the plants. Tobacco smoke is fatal to insects breathing it, and, very often, is used in enclosures infested with plant lice or other delicate insects. Good results have been obtained where tobacco stems have been thrown around trees.

For the San Jose scale we find a 20 to 25 per cent mixture of kerosene and water most satisfactory. For peach and plum the 20 per cent mixture is recommended. Apple and pear will stand a much stronger mixture. It can be put on most effectively when the trees are dormant; but can be applied in 20 per cent mixture even when the trees are in full foliage. This is, at present, the cheapest, and most satisfactory remedy against the San Jose scale in bearing orchards.

*Crude Petroleum.*—This substance has been recommended and used recently against the San Jose scale. The crude oil is sprayed upon the tree while it is dormant. It is no doubt, an effective remedy, but the expensive nature of the crude oil at present, bars it from general use in extensive orchards. It costs from 8 to 13 cents per gallon in barrel or car load lots. When a gallon of this material undiluted, costing, say 10½ cents, is compared with a gallon of refined kerosene costing the same amount, which can be diluted to make 4 gallons of spray, the reasons for not using the crude product are plain. In small orchards, and where only a few trees are to be treated, the crude petroleum can be used to good advantage. It will kill the scale, and whether it is used or not depends upon circumstances and the individual applying it.

*Hellebore.**—The roots of the white hellebore, *Veratrum viride*, are powdered and used as an insecticide, particularly as a substitute for the arsenites. When a few plants are involved this substance is useful; but too expensive for large operations. It destroys insect life, like arsenicals, as an internal poison, and should properly have been placed under that groupe of materials. It is less dangerous to man and higher animals, but would cause death if a sufficient quantity was taken. For cherry slug, rose slug, currant worms and strawberry worms, the powder can be dusted over the plants, diluted with 5 to 10 parts of flour. The application should be made when plants are moist with dew. If used as a spray, 1 ounce to a gallon of water is sufficient.

*Insect Powder.*—The material usually known as insect powder, is known also as Buhach or Persian insect powder. It is the ground up flowers of the Pyrethrum plant. The flower resembles, somewhat our common field daisy. It is now manufactured extensively in California. The killing property of the material is a volatile oil and it should therefore be kept in air-tight vessels. It is not poisonous to man or the higher animals, hence it can be used where poison could not. Its great value is against household pests, such as flies, ants, cockroaches, fleas etc. In small conservatories it can be used to good advantage where poisons are not desireable. It is used as a dry powder or diluted with flour and may be dusted or puffed about a room or over plants. The powder is sometimes burned in an enclosure to destroy mosquitoes quickly. It may be also used in water at the rate of one ounce in 12 gallons of water and should stand about 24 hours before using. For immediate application it can be used in hot water.

*Sulfur.*—Flowers of sulfur is one of the best remedies for mites, such as the red spider etc. It should be applied at the rate of one ounce to a gallon of water or mixed with some such solution as kerosene emulsion. In green-houses a little sulfur sprinkled over the ground occasionally is desirable. If the house contains steam or hot water cover the upper surface of the pipes with sulphur. Burned in poultry houses it is an excellent remedy for the destruction of vermine. Mixed with fresh lard, oil or other grease is a good remedy for lice infesting animals when rubbed over them. Add a little sulfur to the feed of such animals occasionally.

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*This substance properly belongs to the group of biting insects cited on page 57.

*Bisulfid of Carbon.*—This is a foul smelling liquid as clear as water, very volatile, and with fumes heavier than air. It creates a death atmosphere in which no creature can live. It is a specially desirable material for the destruction of insects in stored grains and seeds. A grade, known as "Fuma Bisulfid of Carbon" is sold at about 10 to 12 cents per pound in 25 to 100-pound cans. It can be thrown directly upon the grain or seeds without injuring them either for planting or for edible purposes. For wheat in store, one pound of bisulphide is sufficient for every 100 bushels. If an enclosure is fumigated use one pound to every 1000 cubic feet of space. Place the liquid in a dish or pan and set it on top the grain, making the enclosure as tight as possible. Leave the building closed for 24 hours or longer if possible. Have no lights, not even a lighted cigar or pipe, around when fumigating. Do not inhale the fumes too freely; but get out as soon as possible after the material is applied. It is so inexpensive and so easily handled there would seem to be no good reason why a farmer should have weevily wheat or corn if he has a good tight bin or crib. It is also used in some countries, especially France, for the destruction of under ground insects such as Phyloxera on roots of grape. It is also used to destroy rats and gophers in their burrows in the ground.

*Hydrocyanic Acid Gas.*.—This is one of the most deadly gases known to chemical science, and must, therefore, be used very carefully. It is made by combining cyanide of potassium, sulfuric acid and water. This gas is now extensively used by nurserymen for the fumigation of fruit trees to preclude the possibility of sending out some undesirable insect. It is also used in the orange growing sections of California, Florida, South Africa and other places for the destruction of certain insects upon the trees and fruit. It is now used to some extent in the orchards of the Eastern United States. As a remedy for certain pests in green-houses, dwelling houses, mills, store houses, railway coaches etc., it has no superior as a destroyer of animal life. It diffuses quickly, is lighter than air and very penetrating. It leaves no after and bad effect in a building. It will be more universally used in the future. Persons desiring to use this gas should write to us for more specific information. Its application will admit of no carelessness or guesswork as it is too deadly a poison with which to fool.

There are many patent insecticides, and other materials upon the market, which cannot be mentioned in this bulletin for want of space. The author however, will answer any inquiry about such substances when requested to do so.

# SOME IMPORTANT FUNGI AND FUNGICIDES.

By Charles O. Townsend.

*Introductory.*—In presenting this part of the bulletin the writer has considered it advisable to take up some of the more important questions that have been asked from time to time, in regard to the fungi and fungicides and to answer them as briefly and as pointedly as possible.

## WHAT IS A FUNGUS?

A fungus (plural fungi) is a low form of plant. It has neither green stem nor leaves and therefore depends for its food upon other plants or upon animals. Sometimes fungi live upon dead plants or animals or upon their products, and sometimes they live upon other living plants or upon living animals. They are very numerous and differ greatly among themselves in form structure and habits of life. All fungi sooner or later produce small round or oval bodies called *spores*. These spores under favorable conditions produce new fungi. They are not destroyed by ordinary weather conditions and often live over the winter in the fields and orchards. Sometimes they remain alive for several years in the soil and other suitable places, and begin their growth when the conditions are favorable. Many fungi are very small and can be seen only when greatly magnified.

## WHAT IS THE HOST PLANT?

The host-plant is the plant upon which, or in which the fungus lives and from which it draws its food supply.

## WHAT IS A FUNGICIDE?

A fungicide is any substance which may be used to destroy fungi or their spores or which will prevent fungi from establishing themselves upon the host plants. Fungicides may be either solids, liquids or gases. The most common form of fungicide is liquid; the kind of fungicide used however must depend upon the nature of the fungus, the nature of the host-plant, and the part of the host-plant attacked by the fungus.

## WHY SHOULD WE SPRAY?

Liquid fungicides are best applied in the form of a fine mist or spray.

This is economy both in the quantity of material used and in the time required to apply it. The real object in spraying is to prevent the fungous spores that have lodged upon the foliage, branches or fruit, from germinating and producing fungous growths. Every fungus that grows into a leaf or into a fruit and thus produces the destruction of the former or the decay of the latter first lodges on the leaf or on the fruit as a tiny spore. If that spore can be destroyed without injury to the leaf or to the fruit, disease may be prevented, and therefore the necessity of spraying.

## WHY SHOULD WE SPRAY EARLY?

As already stated fungus spores are sometimes formed in the fall and remain in open fields all winter uninjured. These spores often lodge in the crevices of the bark of trees or in other convenient places on the trunks and branches of trees. When the leaves and fruits appear the spores are blown onto these newly formed parts and cause them to be diseased. The object in early spraying, even while the trees are still dormant, is to kill the spores that are lodging on the tree and waiting for favorable conditions for development. Again, every spore must remain for a longer or shorter time in a dormant state even after it reaches the proper place for its development, just as seeds remain for a little time under proper conditions for germination before they begin their growth. If the leaves or other plant parts are covered with a fungicide before or immediately after the spores are blown onto them, the spores will be destroyed and the plant will remain free from disease.

### WHY IS IT NECESSARY TO SPRAY MORE THAN ONCE?

After a plant has been sprayed new leaves or fruits are often formed which are not covered with the fungicide. Spores may be lodged on these newly formed parts and develop into fungous growths causing the parts attacked to be diseased. Or the fungicide originally sprayed onto the plant may be washed off by rains thus leaving the plant unprotected against the spores that are constantly carried about in the air.

### HOW OFTEN IS IT NECESSARY TO SPRAY?

No definite rule can be given in regard to the number of times any set of plants should be sprayed in a single season. The number of sprayings must depend to a large extent upon weather conditions. Warm, damp weather or a dry, hot season followed by rain, are favorable conditions for the development of fungi, hence if these conditions prevail it is important that the spraying should be frequent enough to keep well protected the parts liable to attack. Sometimes it is necessary to spray every day or every two or three days while at other times ten days may elapse between sprayings. Spraying like cultivation, pruning, and other field operations is largely a matter of judgment, and the more thoroughly the subject is understood the more effective the work will be.

### WHY IS IT NECESSARY TO SPRAY EVERY YEAR?

It is impossible to exterminate fungi. We may hold them in check, or we may even prevent entirely their growth upon certain plants; but they are often so small, their habits of life so variable, and their spores so resistant that extermination is out of the question. It is impossible to know at the beginning of the season whether the conditions will be favorable or unfavorable for the development of fungi, hence in order to be on the safe side it is necessary to begin each season with spraying. It is essential, therefore, that spraying should be as regularly a part of the field work for successful crop raising as plowing, fertilizing, and the other operations necessary for crop production. Furthermore the effects of spraying are cumulative, that is the effects of spraying and keeping fruit trees free from disease this year will give a better crop next year. Even with trucking crops that die down in the fall the danger from disease next year in a particular field will be greatly reduced if the field is kept free from diseases this year.

### DOES SPRAYING SOMETIMES INJURE FOLIAGE AND FRUIT?

If fungicides are not properly made they will burn the foliage and discolor the fruit. It is a well known fact that the foliage on some plants is much more tender than it is on others, and for this reason it is necessary to suit the strength of the fungicide to the host plant. Certain fungicides like Bordeaux mixture can not be used in spraying fruit that is nearly ripe since the fruit would be stained by the mixture and thereby rendered unsalable.

## WHY DOES SPRAYING SOMETIMES FAIL TO PREVENT DISEASE.

There are several reasons why spraying sometimes fails to accomplish the results expected. It may be that the fungicide was not properly made, that the spraying was not done early enough in the season, or that the applications were not thorough or persistent enough. If we wait until we see the disease at work before we begin spraying our efforts will not result in success, for the reason that when we see the disease it is certain that the fungus spores have germinated and the fungus has grown into the affected part of the host-plant. In such cases it is impossible to destroy the fungus without destroying the diseased part of the host. The most that can be hoped for in such cases is that the disease may be prevented from spreading to the healthy plants or plant parts. If the spraying is not thorough so that all parts of the host are covered, spores may fall upon the unprotected parts and grow as readily as if no fungicide had been used. Or if the applications are not frequent enough so that the fungicide is washed off, or new plant parts are developed and left unsprayed, attacks of fungi may take place as readily as if no spraying had been done. It should be remembered that no fungicide will restore any plant part once destroyed or injured, hence the necessity of preventing attacks of fungi, and this can be done only by an early, thorough, and persistent use of fungicides.

## WILL SPRAYING PREVENT ALL PLANT DISEASES?

Several plant diseases, of which "peach yellows" is an example, are not, so far as known, produced by organisms, and these diseases can be neither prevented nor controlled by fungicides.

Other plant diseases are produced by bacteria that live in the tissues of diseased plants. These minute organisms seldom appear on the surface of the host plant and consequently would not usually be reached by spraying. Such a disease is the pear blight. It is often the case that a disease attacks only the under-ground portion of the plant. It is clear that a disease of this nature could not be prevented or controlled by spraying. Potato scab is an example of diseases of this kind. In short, it is only those fungous diseases that originate from spores on the above-ground portions of plants that may be prevented by spraying.

## WILL IT PAY TO SPRAY?

Whether it will or will not pay to spray must depend upon circumstances. It is of prime importance to know whether the plants under consideration are subject to diseases that may be prevented by spraying. If so and the crop is worth raising at all, it is worth bringing to the highest possible state of perfection and it is now well known that spraying, if properly done, is one of the important factors in perfect crop production. However, unless one makes up his mind to use all possibie pains in the preparation of fungicides, to begin spraying early and to carry it on persistently, the time, labor and money expended will be lost. On the other hand, if the fungicide is properly prepared and the work is timely and thorough, it is probable that no equal amount of labor and money expended will yield larger returns, taking it year in and year out. This statement has been demonstrated many times by farmers, gardeners and fruit growers in nearly every section of the state. It is true that certain seasons are unfavorable for the development of fungi, but it rarely happens that they do not develop to some extent; hence it will be an advantage to spray even during such seasons. Experience has shown that it pays to spray systematically and thoroughly, year after year regardless of the season.

## HOW ARE FUNGICIDES PREPARED?

The following directions may be observed in the preparation of common fungicides:

*Ammoniacal Carbonate of Copper.*—Dissolve five (5) ounces of copper carbonate in just enough ammonia water to dissolve it and mix the solution thoroughly with forty (40) gallons of water. In dissolving the copper carbonate it is advisable to dilute the ammonia with eight times its own volume of water. The amount of ammonia required to dissolve five (5) ounces of copper carbonate will depend upon the strength of the ammonia. It will be about three (3) pints. Care should be taken not to add too much ammonia water as an excess will burn the foliage. If properly made this forms a clear fungicide that does not stain the foliage or fruit.

*Bordeaux Mixture.*—Place six (6) pounds of copper sulfate crystals in a coarse bag and suspend it just below the surface of the water in a tub containing twenty-five (25) gallons of water. In a second tub slake six (6) pounds of good stone lime and add enough water to make twenty five (25) gallons. Now pour the two solutions at the same time into a barrel or into the spray pump as shown in Fig. 12, and stir thoroughly. It is advisable to pour these solutions through a sieve of about thirty meshes to the inch. This will tend to mix the solutions more thoroughly and also to remove any particles that might clog the spray nozzle. If these solutions are properly mixed they will hold up as shown in the cylinders in Fig. 13, marked Bordeaux mixture properly made. Otherwise the solid particles will fall as in the cylinders marked Bordeaux mixture improperly

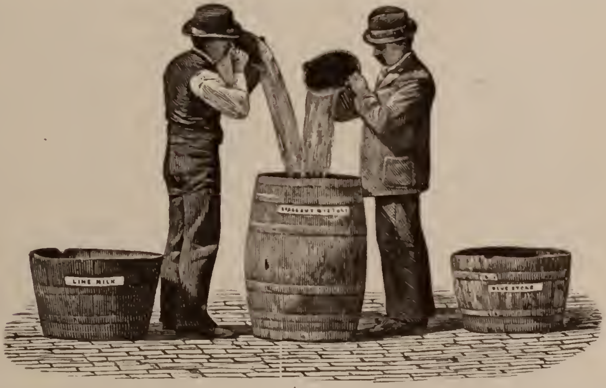


FIG. 12—Proper method of preparing Bordeaux mixture (U.S. Dept. of Agriculture, Division of Botany, Bulletin No. 38.)

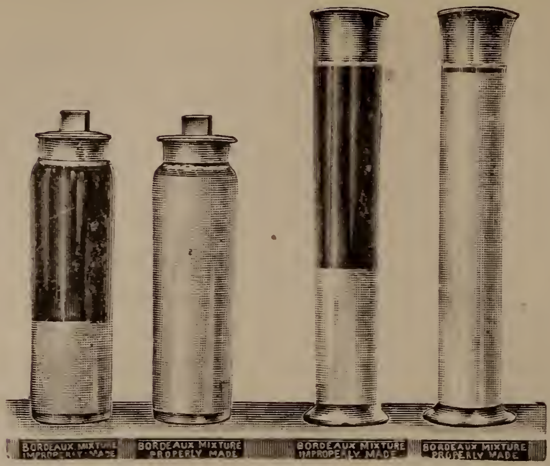

BORDEAUX MIXTURE IMPROPERLY MADE
BORDEAUX MIXTURE PROPERLY MADE
BORDEAUX MIXTURE IMPROPERLY MADE
BORDEAUX MIXTURE PROPERLY MADE

**Fig. 13—Bordeaux mixture properly and improperly made. (U. S. Dept. of Agriculture. Division of Botany, Bulletin No 38.)**

made (Fig.13). This mixture should be used as soon as it is prepared as it quickly loses its strength. If considerable Bordeaux mixture is required for the season it is a great saving of time to prepare stock solutions which may be kept on hand for several weeks. To make stock solutions dissolve fifty (50) pounds copper sulfate in fifty (50) gallons of water. In another barrel slake fifty (50) pounds of good stone lime and add enough water to make fifty (50) gallons. These barrels should be tightly covered to prevent evaporation. When it is desired to make a barrel of Bordeaux mixture stir the stock solution thoroughly, dip six (6) gallons from each barrel and place in separate tubs. Now dilute each to twenty-five (25) gallons and pour together as already directed. The use of the lime is to combine with the copper and form a compound that will not burn the foliage. It also tends to make the fungicide adhere to the plant upon which it is sprayed. To test the mixture to see if all the copper is combined with the lime add a drop of potassium ferro cyanide solution. If it changes color upon coming into contact with the Bordeaux mixture more lime should de added; if it does not change color the combination is complete. In using Bordeaux mixture upon peach or plum foliage it is better to use only four (4) pounds of copper sulfate per barrel instead of six (6). This is the most common fungicide in use at the present time, but it must be remembered that it stains the foliage and the fruit and should therefore not be used when the fruit is approaching ripening season.

*Copper Sulfate.*—Dissolve three (3) pounds of copper sulfate crystals in hot water and dilute to fifty (50) gallons. This is much more easily applied than Bordeaux mixture but it does not adhere so firmly and it *must never be used except while the trees are dormant.* It is useful also in spraying benches and the general interior of green-houses.

*Corrosive Sublimate.—This substance is a deadly poison.* It is prepared by dissolving two ounces of the crystals in sixteen (16) gallons of water.

*Iron Sulfate.*—Dissolve from one (1) to four (4) pounds of the crystals in one (1) gallon of water. If it is required as a spray one pound per gallon is sufficient and the solution should be used only while the plants are dormant. If it is to be used as a wash four (4) pounds per gallon gives the proper strength. If a saturated solution of Iron sulfate is required, it is best to add one part of sulfuric acid to each 100 parts of water.

*Potassium Sulfid* (Liver of Sulfur).—Dissolve four (4) ounces in from four (4) to sixteen (16) gallons of water.

*Sulfur.*—In the dry powdered state this is known as flowers of sulfur. It may be sprinkled over the plants in the dry state or it may be converted into fumes by heating. Care should be taken not to heat it to the burning point as it would thereby form a compound that would destroy green plants as well as fungi. It is usually sufficient to place it upon the hot pipes of the green house.

*Sulfur and Lime.*—Mix the flowers of sulfur with equal parts of powdered lime. This may be used in the same manner as the pure sulfur.

### IN ADDITION TO USING FUNGICIDES WHAT PRECAUTIONS SHOULD BE USED TO HOLD FUNGI IN CHECK ?

Healthy seed and healthy stock are the first requisites for healthy plants. Having secured seeds that germinate readily and vigorously or plants that are not tainted with disease it is important that they should be planted in suitable soil and properly cultivated. The soil should not only contain the necessary food material and the proper amount of moisture but it should be free from fungus spores. If the soil becomes filled with disease-producing spores, plants upon which those spores will germinate and produce disease should not be grown in that particular field for several years. i. e. the crops should be rotated.

It is sometimes possible to make plants outgrow attacks of fungi, for example, from fifty (50) to one hundred (100) pounds of Nitrate of soda per acre sowed broadcast over strawberry plants in the spring will sometimes cause the leaves to outgrow the blight. Badly diseased plants of any kind should not be plowed down but should be gathered and burned. Plants and plant parts especially leaves and fruits that are diseased should not be allowed to remain on the ground or on the trees over winter, either in the field or orchard, but they should be gathered in the fall and burned. Plants affected with incurable, infectious, or contagious diseases should be promptly rooted out and burned.

### DOES FUMIGATING WITH HYDROCYANIC ACID GAS PREVENT FUNGUS DISEASES?

Hydrocyanic acid gas is an insecticide and has no effect upon fungi and fungus spores when used in the ordinary process of fumigating nursery stock or orchard trees. Hence it must be remembered that fumigating with the gas does not reduce, in the least, the necessity for good, thorough spraying with some carefully prepared fungicide.

### WHERE CAN WE GET FURTHER INFORMATION IN REGARD TO FUNGI AND FUNGICIDES.

Futher information in regard to fungi and more explicit directions in regard to preparing and using fungicides may be obtained by addressing the State Pathologist, Maryland Agricultural Experiment Station, College Park, Md.

# SOME IMPORTANT SPRAYING APPARATUS AND OTHER ACCESSORIES.

By Harris P. Gould.

*General Remarks.*—The spray pumps which were at the command of fruit growers and other horticulturists ten or fifteen years ago would hardly be recognized as the prototype of the apparatus at one's disposal at the present time. While no one pump or piece of apparatus can be said to be perfect, or in other words to embody all the good points, yet the fact remains that spraying apparatus, generally speaking, has been brought to a high degree of perfection, and there are now obtainable at moderate cost almost numberless different styles of pumps and other equipment, any one or part of which would doubtless give satifaction to the user.

We are frequently asked by prospective purchasers for our opinion as to the "best" spray pump. As a matter of fact there is no "best." If a man uses a certain kind of plow or binder and becomes accustomed to it, he will usually like it if it does good work. His neighbor across the way may become used to the implements of some other manufacturer and so for him they are better than any other, because he has learned just how to use them. So it is with spraying apparatus. The individual likes and dislikes of the user will help decide what style of pump is likely to prove most pleasing. What one fruit grower may like another may dislike.

However it is hoped by the writer that the following discussion of spraying apparatus may place before the horticulturists of Maryland and others interested in spraying, information that will help them in selecting equipment for this purpose.

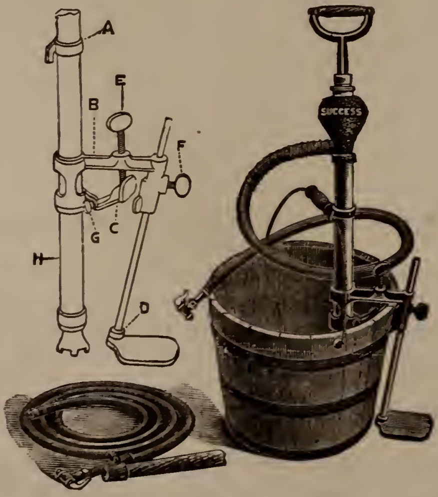


Fig. 14 —A Bucket pump. (The Deming Co.)

## WHAT ARE BUCKET PUMPS?

These are small hand pumps intended for spraying liquids from a bucket. As a rule they are so constructed that the pump itself is placed in the bucket; a foot piece is attached which reaches to the ground and by placing the foot on this, the pump is rigidly held in position while it is being worked. They are useful in many ways about the home and garden.

Nearly every spray pump manufacturer makes pumps of this kind. The cost of the various styles ranges from four or five dollars to nine or ten. They may also be obtained of many hardware dealers.

A satisfactory bucket pump is shown in Fig. 14. The device for attaching the pump to the bucket is shown in the portion of the illustration at the left of the bucket.

## WHAT ARE KNAPSACK PUMPS?

This style of pump is so called because it is carried on the back in the same manner that a knapsack is. It consists of a tank with a capacity of about three or four gallons, into which is fixed a small pump. The latter is so adjusted that it can be operated with one hand. The pump is provided with a small air chamber that insures a steady spray. The details of construction adopted by the different manufacturers vary more or less but the general plan is much the same in nearly all of them.

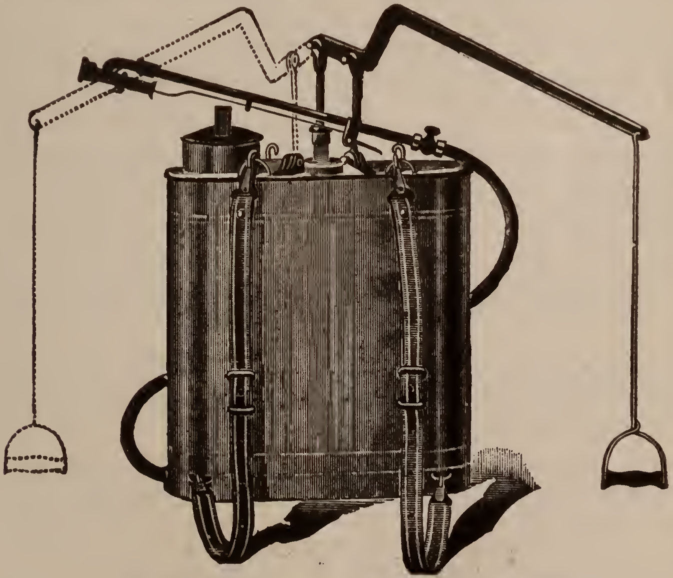


**Fig. 15.—Knapsack pump. (The Goulds Manufacturing Co.)**

Knapsack pumps are adapted for spraying crops like potatoes, grape vines, and other low growing plants, especially if their habit of growth does not admit of free access with heavier equipment.

A large number of different styles are on the market. The prices range from $10 to $15. A knapsack pump is shown in Fig. 15.

## WHAT ARE BARREL PUMPS?

These are pumps intended for mounting on barrels and are without doubt the most important type of spray pump. Nearly all orchard spraying is done with pumps of this class. With proper accessories, they are sufficiently powerful to throw a spray to the tops of all ordinary fruit trees. They are made by a large number of different manufacturers, and while the same principles are involved in nearly all of them the style of construction varies greatly.

On account of the importance of this type of pump, it is well to consider, in connection with this discussion, what the essential features of a good pump are.

*The Air Chamber.*—This is necessary in order to insure a steady spray; without it the spray would be intermittent. Some of the barrel pumps have air chambers unnecessarily large and the pumps are made thereby more cumbersome and heavy than utility demands. A capacity of about one quart will usually be more satisfactory than if larger. In some styles the air chamber is placed on the pump as a separate attachment but the better method is to combine it with other parts of the pump as is shown in Fig. 18.

*Agitators.*—Nearly all of the barrel pumps are provided with some kind of an agitator for keeping the spraying mixture stirred while it is being applied. Though the stirring is necessary, the best means of doing it is a debatable point. Manufacturers commonly make sweeping claims for the effectiveness of their devices, and while these may do the work well, it is a question if a narrow strip of board inserted into the barrel through the hole used in filling the latter, is not preferable to any attachment which can be fastened to the pump. The automatic agitator necessarily increases more or less the labor of working the pump, but with the ladel, the man who operates the pump can stir the mixture frequently with but little inconvenience. The essential point, however, is to keep the mixture thoroughly stirred so that it will be applied at a uniform strength. Any means of agitation which will accomplish this, may be considered satisfactory if it does not unduly increase the labor of operating the pump.

*The Working Parts.*—These are the parts of a pump which are actively concerned in the forcing of the liquid; the valves, plunger, and cylinder are the principle parts referred to.

As many of the spraying mixtures are corrosive in their nature, it is essential that the working parts—those which must fit as closely as possible—be made of some metal not affected in any way by these corrosive materials. Brass is usually employed for this purpose. If iron be used its surface is quickly corroded and the valves and other closely fitting parts made to leak thereby.

*Valves.*—One of the most important features of a pump is the valves. In the older styles these were usually made of leather or had leather packing, and even in some of the newer patterns leather is used in their construction. Such pumps may work well for a time but the leather quickly becomes stiff and hard and requires frequent replacing. Valves made entirely of brass give the best satisfaction.

*General Style.*—While the details of construction may be varied greatly, a few points should be considered. A pump should be compact and so made that when mounted on a barrel as little as possible of the pump shall project above the barrel. If too much of the pump extends above the barrel, it becomes top heavy, easily tipped over when empty or nearly so, and low hanging branches are likely to catch the pump while moving from tree to tree in the orchard.

The majority of pumps are attached to the barrel by means of bolts or screws. These soon become rusty and difficult to remove. Consequently some other means of attaching the pump to the barrel is desirable. A few styles are provided with a clamp or some similar contrivance whereby the annoyance of having to remove rusty screws or bolts is reduced to a minimum.

Cast iron handles are easily broken, if a sudden strain is put upon them, consequently malleable iron or something less easily broken than cast iron is preferable for this purpose.

*Points of a good Pump.*—The points of greatest importance have already been referred to but it may be of convenience if they are brought together under one head.

(1)—The air chamber should be sufficiently large to insure a steady spray and be so placed on the pump that the latter will not be rendered top heavy thereby, nor unduly cumbersome.

(2)—Some means of keeping the spraying mixture thoroughly stirred is essential, but it is not necessary that this be attached to the pump.

(3)—The working parts should all be of brass and be so arranged that they can be examined without undue difficulty.

(4)—The pump when mounted should not extend above the barrel more than is necessary.

(5)—It is desirable to have the device for attaching to the barrel so arranged that the pump can readily be mounted or removed from the barrel.

(6)—The different portions of the pump should be so constructed that they can be readily taken apart, especially those portions which enclose the valves.

(7)—All points for attachment of the hose should be cut with threads of standard size.

*Some Specific Styles.*—A large number of different makes of barrel spray pumps are now on the market. They differ considerably in the details of construction but it will not be necessary to discuss this phrase of the matter at great length. Two or three illustrations will give the reader an idea of this type of pump.

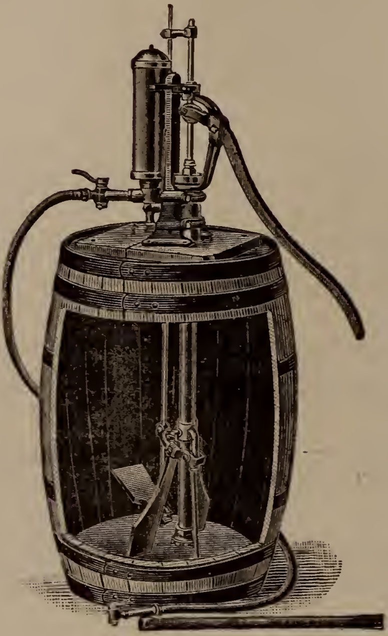


FIG. 16.—The Peerless Pump. (The Deming Co.)

Fig. 16. shows a compact pump of convenient design. While the air chamber is a separate attachment, its moderate size renders this feature unobjectionable. Another style is shown in Fig. 17. The illustration makes the parts sufficiently plain so that no further description is necessary. The cost of this pump is about $8.00. The valves however are not so satisfactory as they are in some other patterns.

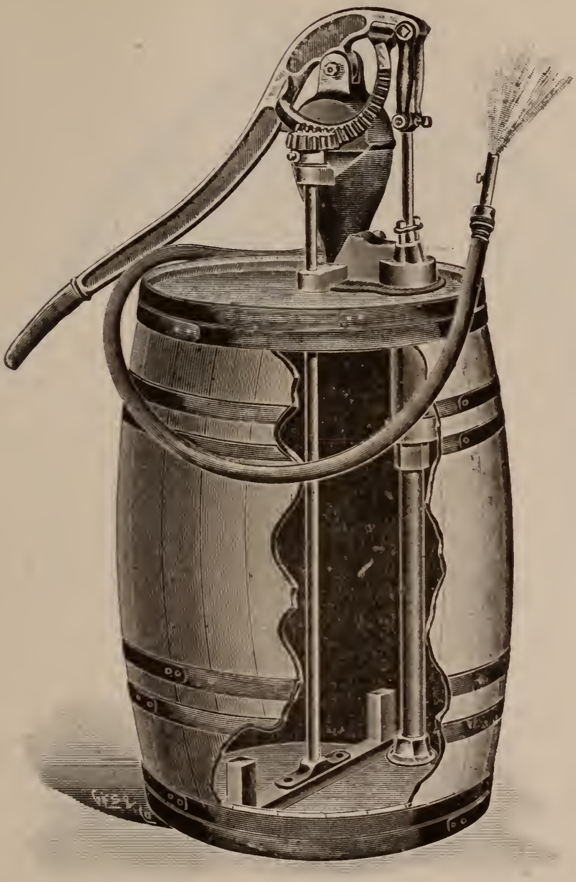


Fig. 17. Empire Queen. (Field Force Pump Co.)

All things considered the design shown in Fig. 18 is one of the most satisfactory now on the market. The air chamber surrounds a tube which extends from the bottom of the pump to the point of discharge. The valves are made entirely of brass and the plunger is a brass cylinder six or eight inches long which works in a pump cylinder made of the same material. It is sometimes necessary to repack the plunger but the construction of the pump renders this a simple and easy matter. This style, pump, only, with working parts of brass costs $15.00. At least three companies manufacture pumps of this same general description.

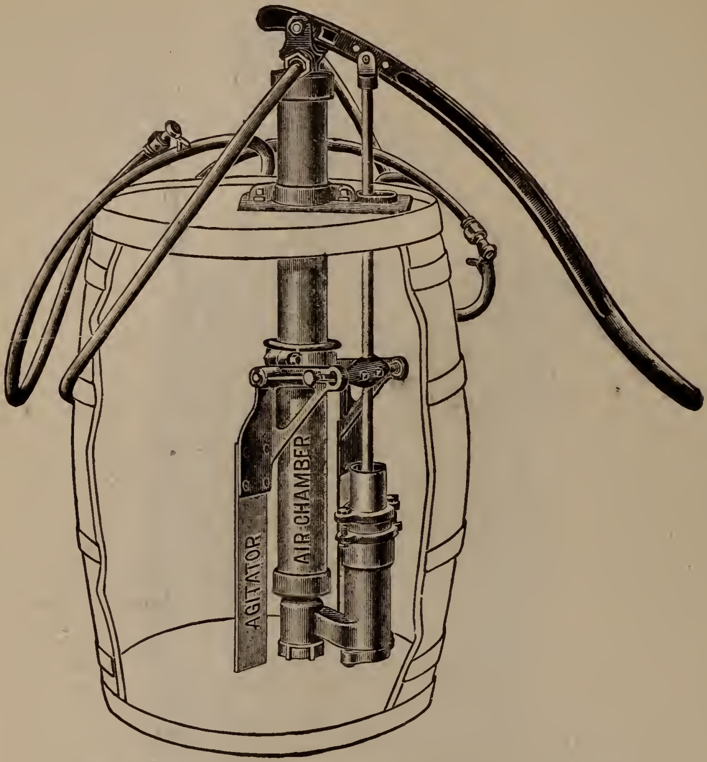


FIG. 18.—The Pomona. (Goulds Manufacturing Company)

## WHAT ARE KEROSENE (COAL OIL) PUMPS?

The increased use of kerosene as an insecticide, during the past few years has brought about an increased demand for some means of applying the kerosene which is more satisfactory than in the form of an emulsion. Several manufacturers are now making pumps by means of which a mechanical mixture of kerosene and water, in any desired proportion, can be produced. Of course the oil and water will separate after a time, but the object of the mixture is in nowise defeated thereby. In fact this mechanical mixture is as permanent as much of the kerosene emulsion which people have been in the habit of using.

These pumps may be had either as bucket pumps, knapsack or barrel sprayers. Two styles with reference to the forcing of the oil, are made In one the oil and water are brought into conjunction with each other by the same pump. The proportion of oil to water is regulated by varying the size of the opening between the oil tank and channel through which the water passes. Fig. 19. Shows a barrel pump of this sort. The cash price of this apparatus varies from $18 to $23.

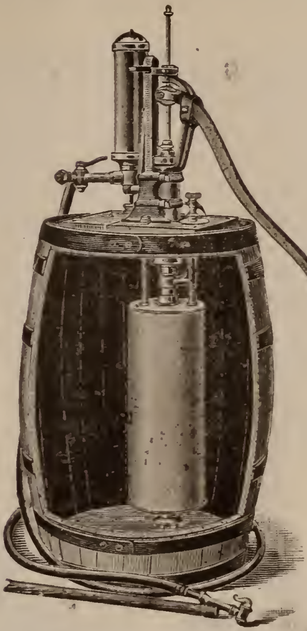


FIG. 19.—A Kerosene pump. (The Deming Company.)

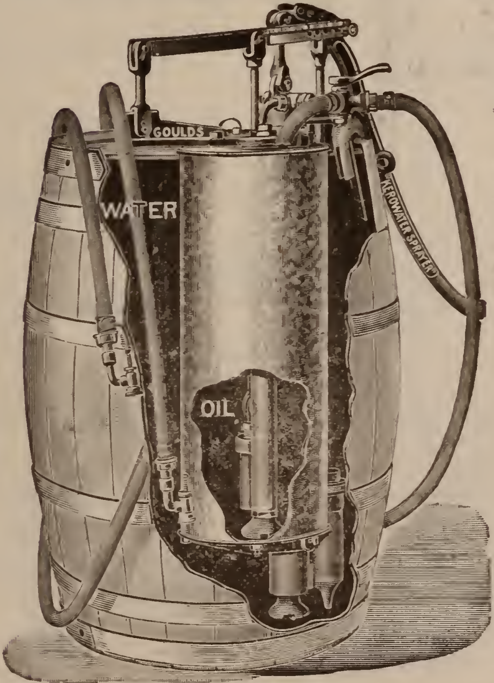


FIG 20.—Another style of Kerosene Pump. (Goulds Mfg Co.)

Fig. 20. shows a kerosene pump in which the oil is worked by an independent pump. The proportions of oil and water are regulated by the relative length of the stroke of the two pistons. The length of the stroke can be regulated to suit the operator. This pump has proven very satisfactory. The pump with or without hose and nozzles costs from $21.00 to $26.50.

### WHAT ARE HORIZONTAL PUMPS?

This type of pump, Fig. 21, is well adapted for extensive orchard spraying. It is much more powerful than the ordinary barrel pump and will supply four leads of hose. The extensive fruit grower who has large orchards to spray and plenty of help, with conditions which make it desirable to complete the spraying as soon as possible, will find this type of machine well suited to his needs. The pump is connected with the tank containing the spraying mixture by means of a suction hose which is shown in the illustration. This pump without any accessories may be bought for about $30.00

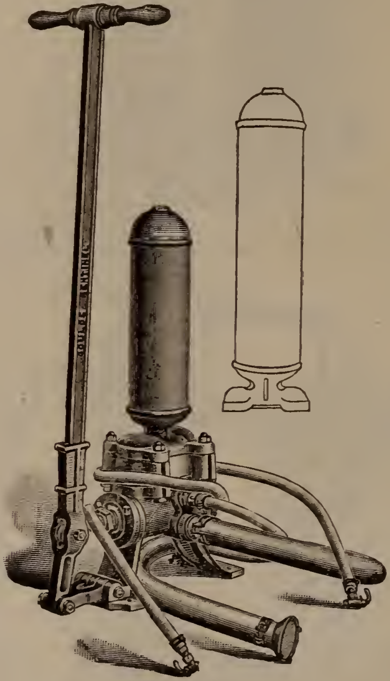


Fig. 21.—The Horizontal type of Spray Pump. (Goulds Mfg Co.)

### WHAT CONSTITUTES A GOOD NOZZLE?

A good nozzle is essential for satisfactory work and other things being equal, that nozzle which will throw the finest spray the greatest distance is the best. The finer and more mist-like the spray is the better, but of course, in actual practice, it is impossible to apply the liquid in the form of a mist. Such a spray could be thrown only a very short distance, and it is often necessary to throw it some ways in treating large trees. But whatever the distance it is necessary to have the spray as fine as possible and still place it where it is wanted.

The shape of the spray as it leaves the nozzle is determined largely by the shape of the orifice and the obstructions which the liquid meets before it is entirely clear of the nozzle. For most purposes a fan shape spray is preferable, though for spraying some plants a cone shape one is desired by some. Nearly all the spray pump makers also manufacture nozzles and many different styles are obtainable. It will be well to refer briefly to some of these.

The Vermorel, Fig. 22, is one of the best nozzles for close work and with proper accessories it may be used for distant work as well. The spray which it makes is fine and mist like; it is a cone-shape spray. Several different manufacturers make the Vermorel. It costs from 75 cents to $1.00. For extensive work like the spraying of trees, a combination of Vermorel nozzles like that shown in Fig. 23 is a useful accessory.

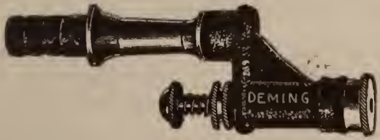


Fig. 22.—The Vermorel Nozzle.
(The Deming Co.)

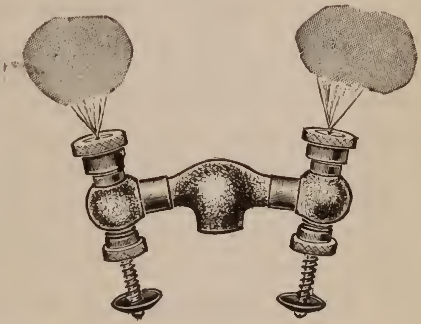


Fig. 23. - Double discharge Vermorel.
(The Goulds Mfg. Co)

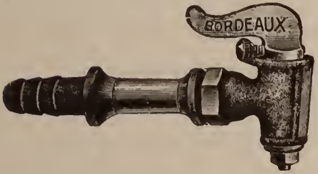


Fig. 24.—The Bordeaux Nozzle
(The Deming Co.)

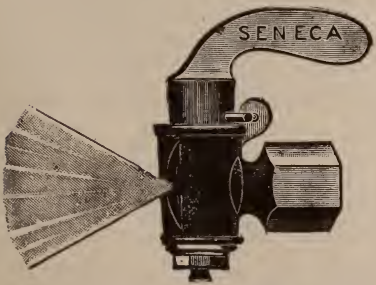


Fig. 25 .—The Seneca Nozzle
(The Goulds Mfg Co.)

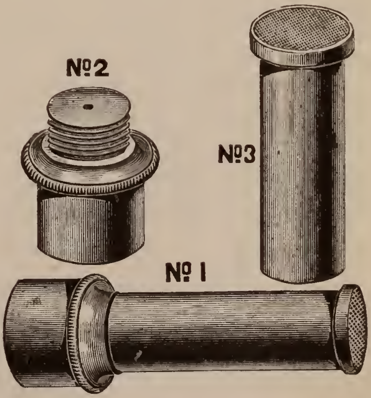


Fig. 26.—The Nixon Nozzle. (Nixon Nozzle and Machine Co.)

Figs. 24 and 25 are nozzles which make a fan shape spray. The size of the orifice through which the liquid passes can be regulated at will, and they are easily cleared if they become clogged. These nozzols cost about the same as the Vermorel.

Fig 26. shows a nozzle of quite a different style from the ones already referred to. After the liquid passes through the orifice (see No. 2.), it strikes against the wire gauze at the outer extremity of No. 3 and is broken up into a spray thereby. The fineness of the spray is regulated largely by the size of the meshes. This style of nozzle has never come into very general use.

For heavy orchard spraying, nozzles that will throw a large quantity of liquids are desirable, though combinations similar to the one referred to are fairly good substitutes. Of the nozzles throwing a larger quantity than any thus far mentioned, the McGowan is one of the most satisfactory. The Gem may also be referred to in this connection.

The cost of nozzles vary considerably but to say from 75 cents to $1.50 will give a fair idea of their value. Combination nozzles cost more. Fig. 23 is listed at $2.00.

## WHAT IS A SATISFACTORY KIND OF HOSE?

A good grade of one-half inch hose is generally preferred for spraying purposes. (This has reference to the inside diameter). Some have used a smaller and lighter hose than this but for powerful pumps and hard usage, the heavier hose is probably the more satisfactory. It is economy in the end to get hose of good quality although the first cost is a little more. Its wearing qualities will more than offset the increased expense. Three or four-ply one-half inch hose will cost 15 cents a foot or more. Woven web hose is also satisfactory for spraying purposes.

## ARE THERE ANY OTHER USEFUL DEVICES?

A great variety of useful accessories are available for the one who wishes the completest outfit possible and some of these are essential to thorough and expeditious work. Only a few of these can be referred to here.

*Extension Rods.*—These are small brass rods or brass tubing encased in bamboo poles for attaching to the end of the hose. By putting the nozzle on the outer extremity it can be raised into the top and high branches of the trees. Various lengths from six to twelve feet are obtainable and the cost varies likewise; from $2 to $4 will be conservative limits.

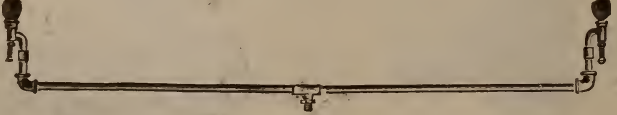


FIG. 27.—Attachment for spraying plants grown in rows. (The Goulds Mfg. Co.)

*Attachments for spraying plants growing in rows.*—Figure 27 gives an idea of a simple arrangement for spraying two rows at time. For potatoes and other low growing plants cultivated in rows this is a convenient device. The hose from the pump is attached midway between the extremeties of the extension. This point may be seen in the figure. Extensions similar to Fig. 27 for spraying four rows may be obtained.

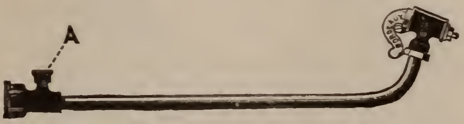


FIG. 28.—A convenient device. (Deming Co.).

*Device for spraying the under side of leaves.*—A simple but important device for this purpose is shown in Fig. 28. The elbow at the outer extremity enables the operator to reach the under side of the foliage with the spray. In spraying for plant lice and other sucking insects this is often necessary.

*Arrangement of a wagon for orchard work.*—Under some conditions the barrel sprayer may be placed on a stone-boat or simple sled-like arrangement made for the purpose and thus moved about through the orchard, but for ordinary orchard work it is more convenient to put the sprayer in some farm wagon and work from this. The work will be greatly facilitated if a platform is built in the wagon which will raise the man who directs the spray four or five feet or more above the bottom of the wagon. A railing should be put around this platform to prevent danger of the operator falling off if the team starts unexpectedly. With a good extension rod and such an arrangement as this for the wagon it is not difficult to throw the spray to the top of ordinary fruit trees. The platform should be so made that it can be readily removed from the wagon.

## WHY DOES A PUMP SOMETIMES FAIL TO WORK?

To the one who is familiar with spray pumps, reference to this matter may be superfluous, but there are many who are at a loss to know what to do when a pump refuses to work properly. Two or three points may be mentioned in this connection.

Sometimes a little sediment becomes lodged under one of the valves, thus causing it to leak. In such a case the pump will not throw its accustomed amount of liquid. Of course the solution of this difficulty is to take the valve out and clean away the obstruction.

A second point and one not infrequently met, is the wearing of the packing which is intended to make the plunger work tightly. If this wears so that the liquid passes up by the plunger, much of the force of the pump is lost, and perhaps, even, the leakage may be so great that no spray whatever can be thrown. In such a case repacking is the remedy.

If a large quantity of lime is used in bordeaux mixture, more or less of it is likely to accumulate in the barrel and clog the strainer at the bottom of the pump. When this happens, if the pump is working as it otherwise should, the handle, upon being raised, will at once be drawn down again with more than usual force.

The operator is sometimes baffled when he first starts the pump, after it has been standing for some time, because it fails to work, although it was working well the last time he used it. This may be due to the valves sticking, perhaps, being cemented in place by the drying of sediment which had collected around the valve when it was used the last time.

There may be other points of difficulty, but these mentioned are the most common sources of annoyance. It is a good plan for the man who gets a new pump, if he possesses ordinary mechanical ability, to take it apart before he uses it and find out just how it is made. By knowing this he can often avoid unnecessary delay and annoyance during the spraying season.

## WHAT CARE SHOULD BE GIVEN SPRAYING APPARATUS?

A word in reply to this question may not be out of place. While spraying apparatus may not be more expensive than many other implements which mean even less to the fruit grower than his spraying apparatus does, yet it is too expensive to neglect.

If the apparatus is to be used every day little or no special care is necessary, but when a job of work has been finished and the pump is to stand unused for several days, all of the spraying mixture should be emptied out of the barrel and clear water forced through the pump, hose and nozzle. This washes off the corrosive mixtures and frees the valves and other parts of all sediment which might otherwise dry and cause delay when the pump is wanted the next time.

At the end of the season when the pump is to be stored for the winter, it ought to be removed from the barrel and taken apart so that all foreign substances may be thoroughly cleaned away. By paying a little attention to these matters the period of usefulness of apparatus may be greatly lenghtened over what it would be if no care is given to the equipment.

## HOW CAN DRY SUBSTANCES BE APPLIED?

While it is usually preferable to apply insecticides and fungicides in liquid form, it is sometimes convenient to use a powder. Several styles of machines for this purpose may be obtained. Perhaps one of the best of the inexpensive forms is that in which a receptical for containing powder is so attached to a small hand bellows that by working the latter the powder is driven out in small quantities. These may be obtained of seedsmen, hardware dealers and others for from $1.00 to $2.00.

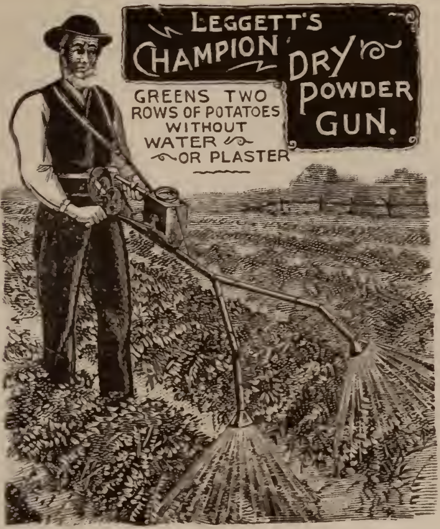

LEGGETT'S
CHAMPION DRY POWDER GUN.
GREENS TWO ROWS OF POTATOES WITHOUT WATER OR PLASTER

Fig. 29.—Apparatus for applying powders. (Leggett Bros.)

Figure 29 shows a good powder gun. The illustration is self-explained. The cost is about $6.00

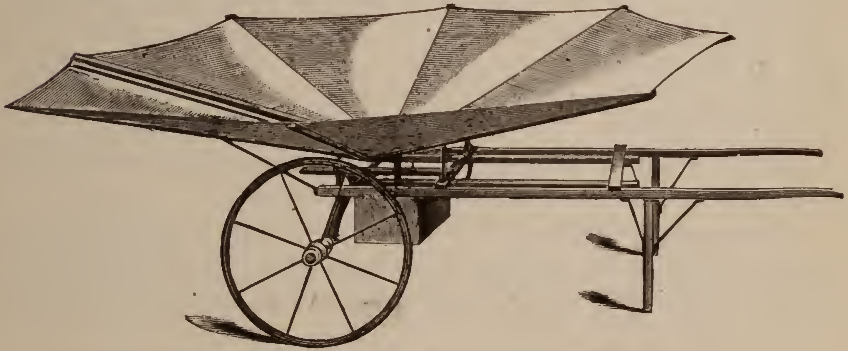


Fig. 30.—Curculio Machine (J. B. Johnson).

*The Curculio Machine.*—This is shown in Fig. 30. It is an inverted umbrella shaped device mounted on wheels and so arranged that when put in position, the trunk of the tree is at the center of the apparatus. A small tank is attached to the lowest point of the machine into which the curculio are brushed from time to time by the operator. A small quantity of kerosene should be put into the tank to prevent the insects from escaping. After placing the machine in position under the tree, the limbs should be jarred by tapping them with a padded stick. If done early in the day, the curculio readily fall from the trees. The machine costs about $15.00

### WHAT PUMP WOULD YOU RECOMMEND?

In our official work, we represent no manufacturers and we do not call attention to any make or style of pump for the purpose of advertising it. But we are frequently asked by those who are becoming interested in spraying apparatus, to recommend pumps to them. In doing so we merely put a pump on its own merits and usually speak from our own experience with spraying apparatus, though of course we cannot try them all.

The catalogues of most manufacturers are well illustrated and it is wise for those who have had no experience with spraying apparatus, to secure several of these and carefully look them over before selecting a pump. To this end, the following list of manufacturers is given;

| | |
|---|---|
| Field Force Pump Co., | Lockport, N. Y. |
| John J. McGowan, | Ithaca, N. Y. |
| W. & B. Douglas, | Middletown, Conn. |
| The Goulds Mfg. Co | Seneca Falls, N. Y. |
| Morrill and Morley | Benton Harbor, Mich. |
| The Caswell Sprayer Co., | Sandusky, Ohio. |
| The Deming Co., | Salem, Ohio. |
| Thos. Pepper | Highstown, N. J. |
| P. C. Lewis Mfg. Co., | Catskill, N. Y. |
| Rumsey and Co., | Seneca Falls, N. Y. |
| Wm. Stahl | Quincy, Ill. |
| Leggett and Bro | New York, N. Y. |
| Bean-Chamberlain Mfg. Co., | Hudson, Mich. |
| F. E. Myers and Bro | Ashland, Ohio. |
| Nixon Nozzle and Machine Co., | Dayton, Ohio. |
| J. B. Johnson | Geneva, N. Y. |

Spray pumps and materials can generally be procured through the local dealers in agricultural implements and supplies.

The materials mentioned in this bulletin for use as insecticides and fungicides can be procured generally of local dealers in agricultural supplies, but the following firms in Baltimore make a specialty of handling them;—

| | |
|---|---|
| Baugh & Sons Company, | 412 Exchange Place |
| Griffith and Turner Co., | 205 North Paca St. |
| Hanline Bros., | 23 South Howard St. |
| Powell Fertilizer & Chemical Co. | 306 Water St. |
| Theo. Smith, | 800 West Baltimore St. |
| Thomas & Thompson, | Cor. Baltimore and Light Sts. |

It has been considered advisable not to give prices on these materials, since there is more or less fluctuation from time to time and the price also varies with the quantity of material purchased. It is suggested that persons desiring any of the insecticides or fungicides write to dealers and procure quotations before purchasing.

# SPRAY CALENDAR AND OTHER SUGGESTIONS.

Only the most important insects and diseases, those which may be expected to occur every year, are considered in this brief outline. The treatment here recommended should be considered as an *insurance* of the crop or a *preventive* against the ravages of disease and insects rather than a cure for the same. In following these directions many lesser pests will also be controlled aside from those specifically mentioned.

*Note.*—When Paris green* is mentioned it should be understood that the application intended is at the rate of 1 pound to 150 to 200 gallons or for general spraying 1 pound to 160 gallons. Whenever it is advised to use Paris green and Bordeaux mixture at the same time, they may be applied together, the latter being put in the Bordeaux instead of water. The figures of the text refer to the number of the application. If an application is immediately followed by a rain sufficient to wash off the mixture, it should be repeated. Applications in parenthesis are least important and may be omitted if in the judgment of the operator they are unnecessary.

***London purple arsenate of lead or green arsenoid can be substituted for the Paris green. See page 57.**

### APPLE.

DISEASES—*Scab.*—1. [Bordeaux just as leaf buds begin to expand]. 2. Bordeax when leaves are fully expanded but before blossoms open. 3. repeat 2 immediately after falling of blossoms. 4. Repeat 2 in about two weeks. 5. Repeat if necessary. *Rust.*—Same as for scab, 2d and 3d being of greatest importance. As one stage of the disease is passed on cedar trees, the removal of these, where practicable, will prevent its spread. INSECTS—*Codling moth.* 1. Paris green in Bordeaux immediately after blossoms fall (see page 58). Repeat within a week to 12 days according to weather, and before the fruit turns calyx end downwards. 3. Keep fallen fruit picked up. *Canker Worm. Tent Catapillar.* Paris green as soon as insects appear; can usually be applied with Bordeaux. 2. Repeat in four or five days if insects still remain. *Bud Moth, Case Bearer.* 1. Paris green as soon as tips of expanding leaf buds apppear. 2. Repeat 1 before blossom buds open. *Borers.* These cannot be controled by spraying. The trees, especially young orchards should be frequently examined during the summer and the borers dug out.

### ASPARAGUS.

DISEASES.—*Rust, Leopard Spot.* These diseases are difficult to control. Keeping the growth well sprayed with Bordeaux after cutting ceases and mowing the tops and burning in the fall are recommended. INSECTS—*Asparagus Beetle.* Allowing a series of "trap plants" to grow during the cutting period and destroying some of them every week will probably reduce the damage somewhat. Spraying old beds with Paris green or dusting them with land plaster and Paris green when dew is on, after the cutting season is over, will also check the pest. Spraying young plants with Paris green in water when the larvae appear or dusting with land plaster and Paris green is recommended (see page 58). Jarring or sweeping (with broom-like brush) the larvae from the young plants during midday in hot sun, is recommended. In sandy soil many larvae are destroyed in this manner.

## CABBAGE AND CAULIFLOWER.

DISEASES—*Club-foot.* Rotation of crops. Do not grow cabbage or similar plants on infested soil for two or three years. INSECTS. *Cabbage-worm, Plusia.* Use Paris green, either dry or in water; the dry method is preferable,[see page 58] whenever insects appear in destructive numbers until heads are half grown. If latter applications are necessary, use hellebore [see page 62] *Harlequin or terrapin bug.* The sowing of kale as a trap-plant, between the rows or about the field is suggested. Hand picking. Kerosene emulsion to destroy young bugs [see page 60]. Paris green will not destroy these insects.

## CELERY.

DISEASES—*Blight.* 1. Bordeaux or Ammoniacal solution of copper carbonate as soon as plants become well established. 2, 3, etc. Repeat 1 every week or often enough to keep foliage well covered, until danger of disease is past. INSECTS—*Celery caterpillar.* Paris green as soon as insect appears, especially while plants are young.

## CHERRY.

DISEASES—*Black-knot.* 1. As soon as discovered cut off affected parts, if on small limbs eight or ten inches below the point of infection, and burn. 2. Frequent applications of Bordeaux after cutting out will have a tendency to check the spread of the disease. *Fruit-Rot.* 1. When leaf buds are opening, Bordeaux. 2. Repeat 1 when fruit has set. 3. Ammoniacal solution of copper carbonate in a week or ten days after 2 [to avoid staining fruit]. 4. Repeat 3 every week if weather is hot and muggy. INSECTS—*Slug.* 1. Paris green as soon as insects appear, or dust insects with air slacked lime or even road dust. 2. Repeat 1. in three or four days if insects still persist. One pound whale oil soap in four to five gallons water, or hellebore [see page 62].

## CUCUMBER, CANTALOUPE AND SQUASH.

DISEASES—*Blight, Mildew.* 1 Bordeaux mixture as soon as plants become well established. 2. Repeat 1 often enough to keep vines well covered with Bordeaux until danger of diseases is past. . INSECTS—*Striped Cucumber Beetle, Spuash bug.* Plants covered with Bordeaux are seldom seriously troubled. This merely drives the insect away. It must be applied as soon as plants are out of the ground. Dusting the plants with air-slaked lime, ashes or soot is also recommended. *Melon plant louse.* Kerosene mixture or kerosene emulsion [see page 60]. The destruction of badly infested plants.

## CURRANT.

DISEASES—*Blight.* 1. Bordeaux as soon as fruit has set. 2. Repeat 1 in ten to fifteen days. 3. Ammoniacal solution copper carbonate when fruit is reaching full size. 4. Bordeaux after fruit has been picked. INSECTS—*Currant worm.* 1. Paris green, dry application [page 58] as soon as insects appear. 2. Repeat 1. within a week if necessary. 3. If insects reappear after fruit is half grown, use hellebore [see page 62].

## EGGPLANT.

DISEASES,—*Leaf-spot.* 1. Bordeaux as soon as plants are fairly established in field. 2, 3, Repeat every two or three weeks until fruit is half grown. 4. Ammoniacal copper carbonate solution to avoid staining fruit. Repeat when necessary. INSECTS—*Potato bug* and *Flea beetle.* 1. Paris green, dry method, as soon as insects appear. 2. Repeat when necessary.

## GOOSEBERRY.

DISEASES—*Mildew.* 1. Bordeaux as soon as growth begins. 2. Potassium sulfid when leaves are expanded. 3. 4, etc. Repeat 2 every ten or twelve days until danger is past. INSECTS—*Currant worm.* See under Currant.

## GRAPE.

DISEASES—*Anthracnose.* 1. Sulfate of iron and sulfuric acid solution before buds break in spring. 2. Repeat 1 in a few days if untreated portions of vines are detected. *Black Rot.* 1. [Bordeaux as soon as first leaves are expanded]. 2. After fruit has set, Bordeaux. 3. Repeat 2 often enough to keep foliage well covered with Bordeaux until fruit is three fourths grown. Ammoniacal solution of copper carbonate when fruit is nearly grown. 5, 6, etc. Repeat 4 every two weeks or so until near harvest. *Downy Mildew, Powdery Mildew.* Same as for Black-Rot, except that first application is important. *Ripe-Rot.* Later applications under *Black Rot* are important. INSECTS—*Grape-vine Flea beetle.* 1. Paris green in solution, [page 58] very thoroughly applied as buds are swelling. 2. Repeat 1 in a few days if necessary. 3. When larvæ appear on leaves dust on air slacked lime, or spray with Paris green. Hellebore can be used also [see page 62].

## PEACH.

DISEASES—*Brown Rot.* 1. Before buds swell, copper sulfate solution or Bordeaux. 2. Bordeaux after fruit has set. 3. Repeat 2 every ten or fourteen days until fruit is nearly grown. 4. Ammoniacal solution copper carbonate after fruit is nearly grown. 5, 6, etc. Repeat 4 as often as necessary until fruit is picked. *Fruit Spot.* Same as for *Brown Rot*, except that first application may be omitted. *Leaf.Curl.* 1. Bordeaux after buds swell. 2, 3, Repeat 1 at intervals of ten days or so. The first two applications most important. *Yellows.* Dig up and burn infested trees. INSECTS—*Borer.* Dig out the worm late in the fall, and mound earth about the trunk of tree. *Curculio.* Spraying is not effective. Jar the trees after fruit has set every day or so for two or three weeks, or until no more insects are found. A Curculio catcher [see page 83] should be used; the insects collected and killed.

## PEAR.

DISEASES—*Twig-Blight.* Cut off affected twigs ten or twelve inches below affected part as soon as discovered and burn. *Scab.* See under *Apple. Leaf-blight, Leaf-Spot.* Same as for *Scab.* INSECTS—*Pear leaf blister* mite. Before buds start in spring, kerosene diluted 10 to 12 times.

Burning the branches after pruning will also lessen the number. *Psylla.* 1. Kerosene diluted 12 to 15 times, as soon as leaves have unfolded. 2, 3, etc. Repeat 1 every two or three days if necessary. *Slug.* See under. *Cherry Codling-moth.* See under *Apple.*

## PEAS.

INSECTS—*Destructive Green Pea Louse.* Kerosene diluted 10 to 12 times with water, [see page 70]. Air slaked lime or tobacco dust when vines are damp.Paris green has no effect upon this insect. Destruction of volunteer and very late peas.

## PLUM.

DISEASES—*Brown-rot.* See under *Peach. Shot-hole fungus.* 1. Bordeaux as soon as leaves have unfolded. 2, 3, etc, Repeat 1 every ten or 15 days until fruit is three-fourths grown. 4. Ammoniacal solution of copper carbonate after fruit is nearly grown. *Black-knot.* See under *Cherry.* INSECTS—*Curculio.* Use the Curculio catcher and jar the trees regularly [see page 83 Fig. 30].

## POTATO.

DISEASES—*Early Blight.* 1. Bordeaux when tops one-half or two-thirds grown. 2, 3, etc. Repeat 1 three or four times at intervals of about 10 days. *Late Blight* or *Rot.* 1. Bordeaux about the middle of July, 2, 3, etc. Repeat 1 four or five times at intervals of about 10 days. *Scab.* 1. Avoid planting potatoes on soil known to be infested with the disease. 2. If seed is scabby, soak for one and one half hours in solution of corrosive sublimate, using one ounce of sublimate to eight gallons of water. INSECTS—*Potato Bug.* Paris green either dry or with Bordeaux as soon as insects appear. 2. Repeat 1 if necessary. *Potato stalk Weevil.* Burn all vines in infested fields. Insect lives over winter in the hollow of the vines.

## QUINCE.

DISEASES—*Leaf-blight* or *fruit-spot.* 1. Bordeaux as soon as blossom buds appear. 2. When fruit has set repeat 1. 3. Repeat 1 at intervals of two weeks or so, until fruit is nearly grown. 4. If later applications are necessary, use ammoniacal solution of copper carbonate to avoid staining the fruit. INSECTS—*Curculio.* See under *Plum.* [Use the Curculio catcher, see page 83]

## RASPBERRY, BLACKBERRY AND DEWBERRIES.

DISEASE—*Anthracnose.* 1. Copper sulfate solution before growth begins. 2. Bordeaux after growth commences. 3. Repeat 2 every ten days or so until fruit approaches maturity. 4. Ammoniacal solution copper carbonate to avoid staining fruit. 5. After fruiting, Bordeaux on young cones, at intervals of two or three weeks throughout the season. Apply to canes as well as to foliage. Cut out and burn diseased canes. *Orange rust.* Dig up and burn all diseased plants. INSECTS—*RoseScale.* Cut and burn infested canes, and spray in May with 10 to 12 per cent kerosene [see page 60].

## STRAWBERRY.

DISEASES—*Leaf-blight* or *rust*. 1. Bordeaux as soon as growth begins. 2. Repeat 1 in about two weeks. 3. Ammoniacal solution of copper carbonate after fruit has set. 4, 5, etc After fruit is picked, Bordeaux every two or three weeks throughout the season. New beds, Bordeaux every two or three weeks throughout the season after plants become well established. *Mildew*. 1. Potassium sulfid as soon as growth begins. 2, 3, etc. Repeat 1 every week or ten days until fruit approaches maturity. An occasional application after fruit is picked, if necessary. INSECTS—*Root louse* or *aphis*. Tobacco dust around plants. Plow down badly infested fields. *Leaf-roller, slug, etc*. Paris green in Bordeaux as soon as first insects appear. *Weevil*. No satisfactory remedy known.

## TOMATO.

DISEASES—*Blight*. 1. Bordeaux mixture once or more while in seed bed. (This is very important) 2. Repeat 1 as soon as plants are well established in the field. 3, 4, etc. Repeat every ten or fifteen days until fruit approaches maturity. INSECTS—*Tomato worms*. Use Paris green in Bordeaux. Hand picking—*Old fashioned Potato Bug*, Paris green. They can be driven out of a field with a broom or brush.

## GENERAL RECOMMENDATION.

Several insects infest a great variety of host-plants and so have not been mentioned in the foregoing recommendation. The ones mentioned below may be treated as described, wherever found.

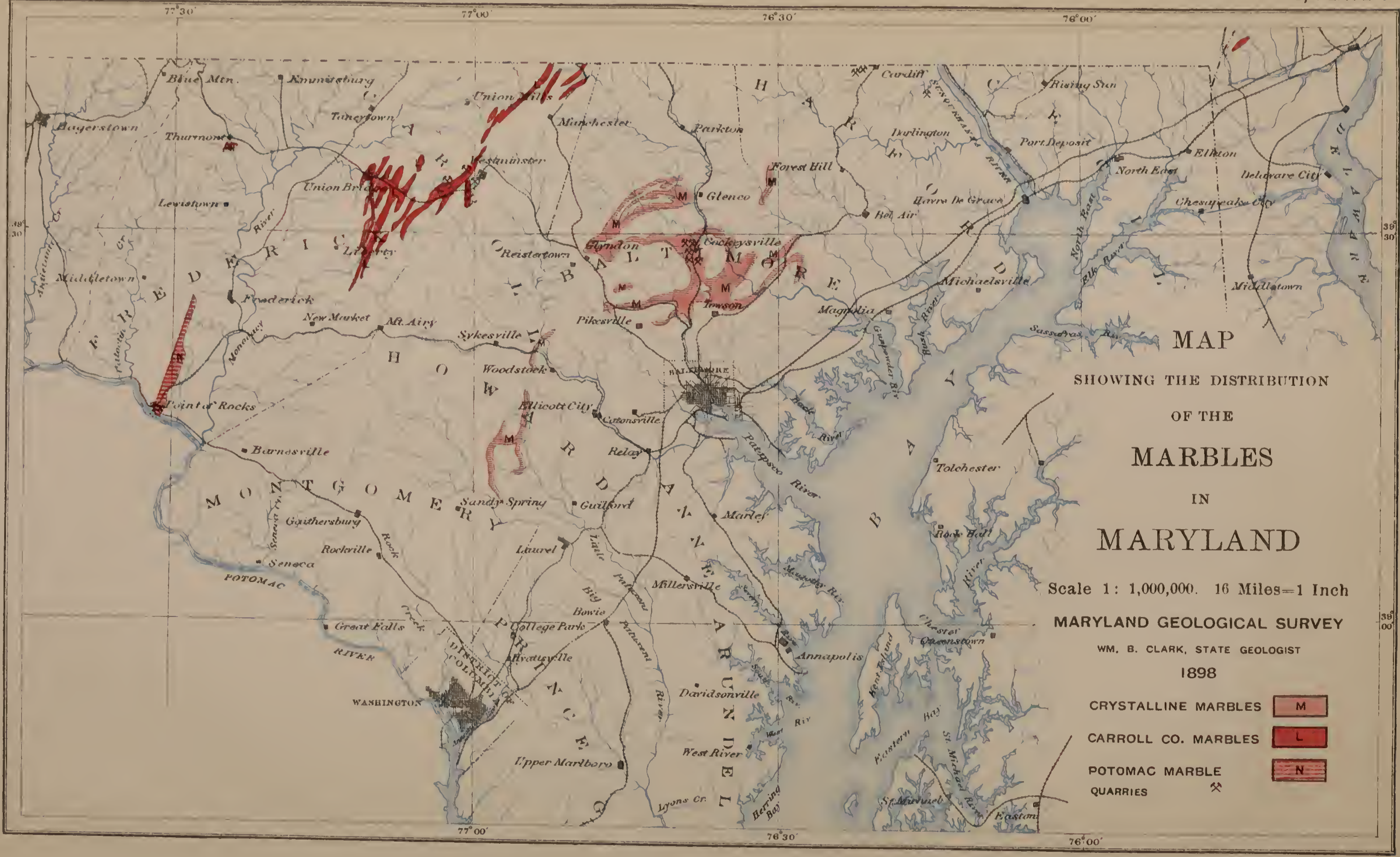
*Aphids* or *Plant Lice*. As soon as the insects appear in destructive numbers spray with kerosene diluted 10 to 12 times or some other insecticide which kills by contact: such as soap solutions, tobacco decoctions, tobacco dust or insect powder [see page 60].

*San Jose scale* and *other scale insects*. Treat with 20 per cent or 25 per cent mechanical mixture of kerosene and water, or whale oil soap, two pounds to a gallon of water. The 25 per cent must be applied when the trees are dormant. Though the 20 per cent solution may be applied when the trees are in foliage, it is best to treat them during their dormant condition. Kerosene [page 60] should be applied on a bright, sunny day. Crude petroleum can also be used [page 62]. For the destruction of insects in stored grain, use Bisulfid of Carbon. For its preparation and application [see page 63].

Insects in mills and elevators, use hydrocyanic acid gas; but consult us before applying it, and get specific directions [see page 63].

*Cockroaches* can be destroyed by mixing one part of plaster of Paris and three to four parts of flour together, placing it in plates where the insect can get at it. Near by set a plate or pan containing water, so that the insects can drink freely.

It is well to supply several bridges from the flour-plaster to the water by means of narrow strips of light boards. The insects eat the material, then drink the water, after which the plaster sets and clogs their intestines, thus killing them. It is a simple and effective remedy.



LITH. BY A. HOEN & CO. BALTO.

# THE MARYLAND
# AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 66. MAY 1900.

## The Occurrence and Composition of Lime in Maryland, Together with a Report of the Results of Experiments in Testing Its Use in Agriculture.

BY H. J. PATTERSON, DIRECTOR AND CHEMIST.

### PREFACE.

The matter contained in this bulletin is based chiefly upon the results of investigations conducted at this Station as to the composition and sources of lime in Maryland available for agricultural purposes, and of the results obtained from the series of field experiments conducted during the past twelve years with different forms of lime; also the quantities and methods of applying the same. Some of these results have been reported from time to time in the regular publications of the Station, but the bulk of this matter is presented now for the first time.

We are indebted to Prof. Wm. B. Clark, State Geologist, for the samples of lime-stone representing the various Geological formations and deposits in the State. The chemical analysis of most of these samples was made by Mr. Thomas Malcolm Price, Assistant Chemist of the Station.

### GENERAL DISCUSSION OF THE RELATION OF LIME TO AGRICULTURE.

Lime was one of the earliest materials used for improving the productiveness of the soil, as is evidenced by the writings of Pliny and Cato. It was used in this way probably two or three hundred years B. C. That chalk and marl were quite extensively used at an early period in Southern Europe is shown by the notes of Varro, taken during the march of his army to the Rhine. The contributions of Ruffin in the "American Farmer" as early as 1818, show that the agricultural use of certain forms of lime took a prominent place in the agriculture of the United States early in its history.

Although lime was thus used early in the history of agriculture, and has been used to a greater or less degree in all parts of the agricultural world ever since, yet the nature of its action on the soil is but little understood and has been but slightly studied. Almost every one recognizes the fact that there is a great difference in the action of lime on soils of different characters. That there is a difference between the action of limes of different character and composition on the same soil is a point seldom noticed.

The term *"lime"* is generally understood to mean quick or caustic lime or Calcium Oxide (CaO). When any form of carbonate of lime; lime-stone, oyster shells, or shell marl, is burned, the carbonic acid is expelled and lime or quick lime is produced. In burning, the Calcium (lime) carbonate ($CaCO_3$) undergoes decomposition, carbonic acid being thrown off, and caustic quick-lime (Calcium Oxide, $CaO$) remaining in the kiln. The fuel generally used in burning lime is wood, charcoal, coal or coke, and the ashes from these will be found as impurities in the lime.

The kiln may consist of only a crude pile of logs, and wood so arranged as to admit the air and burn freely with the stone or shells piled inside and on top. They may vary in form and construction, all the way from this crude type to those constructed of extensive and solid masonry or steel boiler plate lined on the inside with fire-brick, and so arranged that lime may be perpetually drawn from the bottom while the stone and fuel are being fed at the top. While the types, sizes and details now in use vary considerably, yet the general form most approved is not very different from the description given by Cato. Some limes are burned in retorts, pots or crucibles, thus giving a pure lime, free from the contamination of ashes and unburned fuel.

*Lime Burning:*—Lime-stone or any carbonate of lime begins to decompose at about 300° C., and the temperature usually employed is indicated by a bright red heat. It ought not to exceed 1100°C, The facility with which lime is burned depends upon the porosity and composition of the stone, the size of the lumps and the volume of air passed through the burning mass. Again the expulsion of carbonic acid is facilitated by the introduction of steam into the mass. This is accomplished by practical lime burners by watering lime-stone which has become dry by standing in the open air.

About one bushel of coal is required to make five or six bushels of lime, but dolomitic (Magnesium) lime-stones require less. If much argellaceous matter is present the lime-stone more readily fuses, and in such cases, great care should be exercised to keep the temperature below the melting point, otherwise the mass vitrifies and the lime resulting is said to be "dead burnt" or "over burnt." "Over burning" may also be due to the forming of a half-burnt lime by a strong and sudden ignition, or by means of high temperatures the silica and alumina, contained in the lime-stone, will become sintered over the surface of the lime, forming a slag or glass which prevents its coming in contact with the water and slacking.

From this it will be seen that the same conditions and heats can not be applied to all classes of lime-stones, and that it is necessary to take extra precautions when burning lime-stone of irregular character and composition. In fact it is well not to attempt to burn different veins of lime-stone in the same kiln at the same time. If it is desired to market different grades or veins of lime-stone, and at the same time place only one grade of lime on the market, these should be burned separately and combined after burning. Such a process, if carefully carried out, would prevent much of the trouble in lime slacking unevenly. It is well to have dampers in the kilns, to put the heat better under control.

In burning, lime-stone retains practically the same volume, but loses about 44 per cent in weight; that is 100 pounds of stone yields about 56 pounds of lime.

*Characteristics of Lime*:—It is common to hear the terms "Agricultural lime" and "Building lime," used as if these were different articles. In reality, no such difference exists; they are simply trade terms; as the same lime is generally used indiscriminately for the two different purposes. Sometimes, however, the name "Agricultural lime" is used to mean building lime that has been air or water slacked, and again it refers to the quality of the stone from which it was derived. If it were always thus used the term would have a distinct meaning. Unfortunately it is impossible to define or distinguish a building or agricultural lime even from a chemical standpoint, owing to the fact already stated that different soils respond differently to the same lime and *vice versa*. According to the nature of the lime-stone, it will turn out (a) a fat or rich lime; (b) a poor lime; or (c) an hydraulic lime. If lime-stone consists simply of pure Carbonate of Lime, then the lime obtained therefrom will slack readily, forming a creamy mixture with water, and is called fat or rich lime. On the other hand if the lime-stone contains Magnesia it slacks more slowly, forming a thin, poor mixture and is called a poor lime. With ten per cent (10 per cent) of Magnesia a lime is poor, and with twenty-five to thirty per cent it is almost useless. If the lime-stone contains more than ten per cent of silica the lime therefrom will have the quality of forming a paste, which will harden under water or in most places where it is not exposed to the drying influence of the air; such lime is known as hydraulic lime. It is very reasonable to suppose that the different limes act differently on the same soil or on soils of different characters, and much in the same manner as they do in forming mortars and cements.

## KINDS OF LIME USED IN AGRICULTURE.

*Stone Lime.*—Good lime-stone contains from 50 to 55 per cent lime (CaO), and 40 to 45 per cent Calcium (lime) Carbonate, with small amounts of Magnesia, silica, iron and aluminia. Such lime, when burnt, would produce the best quality of caustic or quick-lime, and would contain from 90 to 98 per cent of Calcium Oxide (CaO). Freshly burned lime, when removed from the kiln, will weigh about 90 or 95 pounds to the heaped bushel, and will slack about three bushels for one in volume.

*Magnesia Stone Lime*:—Magnesia lime-stone, or dolomites are quite varied in their composition, and may range in Carbonate of Lime from 20 to 80 per cent, and in Carbonate of Magnesium from 10 to 60 per cent. The average of such lime-stones used in agriculture, when burned, will produce a lime containing from 70 to 85 per cent of Calcium Oxide and 5 to 20 per cent of Magnesium Oxide. Magnesia lime weighs about 75 to 85 pounds to the heaped bushel, and will slack about two bushels for one, by volume.

*Oyster Shell Lime:*—Oyster shells contain from 90 to 95 per cent of Calcium (lime) Carbonate, and will produce, when burned, a comparatively pure lime, which should contain from 85 to 95 per cent of pure Calcium Oxide if it has not been excessively contaminated with the ashes from the fuel in burning. Freshly burned Oyster shell lime weighs about 60 pounds per bushel, and will slake out a little better than two for one by volume.

*Slaked Lime*:—In the process of slaking lime it takes up water and forms Calcium or Lime Hydrate. It also absorbs some Carbonic Acid from the air and forms Carbonate of Lime. If different samples of lime or slaked lime are in equally good condition they may be thus compared:—

| Kind of Lime. | Wt. per bu. before slaking. | Total Wt. after slaking. | Number Bu. after slaking. | Wt. per Bu. after slaking. |
|---|---|---|---|---|
| Good stone lime | 93 lbs. | 135 | 3 | 45 |
| Magnesia stone lime | 80 " | 110 | 2 | 55 |
| Oyster shell lime | 60 " | 100 | 2½ | 40 |

*Gas House Lime or Gas Lime:*—Quick lime is used at the gas works for removing the impurities of the gas. After it has been saturated with the impurities, and no longer fit for use in gas making, it is sold for agricultural purposes under the name of gas-lime. This article varies considerably in composition, but consists essentially of the hydrate, carbonate, sulphate, sulphides and sulphites of lime. The sulphides and sulphites of lime are injurious to germinating seeds or young and tender plants, so that gas lime should be applied cautiously and when not too fresh. The action of the air on sulphides and sulphites changes them to sulphate of lime (gypsum or land-plaster); hence the exposure of gas-lime to the weather for some time improves its agricultural qualities. Average gas-lime contains about 22 per cent water, 43 per cent lime (CaO), 21 per cent Sulphuric Acid (Oil of Vitriol), 8 per cent Magnesia, and 6 per cent insoluble matter. Of course this will vary considerably according to the character of the lime used, and the amount and nature of the impurities. The gas houses in Baltimore and Washington, D. C., use mostly Oyster shell lime, and the gas lime from such lime would contain very much less Magnesia than indicated by the average figures. Gas-lime is usually sold at 65 pounds per bushel.

*Gypsum or Land Plaster* is a combination of lime with Sulphuric Acid (Oil of Vitriol) forming sulphate of lime. It occurs in nature in large deposits forming beds of rock. These are comparatively easily mined, and the rock is ground to a fine powder for commercial purposes. It varies in color from white or light yellow to gray. There are no natural deposits of gypsum in Maryland, Gypsum or sulphate of lime is formed artificially in the manufacture of phosphoric acid and phosphates, by treating the phosphates of lime with sulphuric acid, and a considerable amount of gypsum is necessarily used in agriculture in using dissolved bone and dissolved rock. Average gypsum contains about 32 per cent Calcium Oxide (CaO).

*Marl*, is a name applied to earthy deposits containing more or less partially decomposed shells. These make the marl more or less friable or easily disintegrated by the weather. Marls are valuable as sources of carbonate of lime, and, when they contain large amounts of lime, they are burned and thus furnish a source of quick-lime. Marls occur widely distributed in Maryland, and vary considerably in character and quality, as will be seen from the discussion and analyses in table VII..

*Phosphates of Lime,* are used extensively in agriculture, being furnished through the medium of bone, South Carolina, Florida and Tennessee phosphate rock, slag phosphates, and various guanos. These are really used for their phosphoric acid rather than for lime, and so are somewhat outside of the province of this bulletin.

### MODES OF ACTION OF LIME.

In considering the question of the use of lime from a theoretical standpoint it would be very natural to conclude that lime is a necessary plant food. Lime is a substance that is just as essential to the plant as Nitrogen, Potash or Phosphoric Acid, and some of it must be present in the soil or no crop can grow. Nevertheless the requirements of the crop in this respect are very small, and but a few pounds of any lime compound per acre would suffice for any crop.

Lime is one of the most abundant substances. It has been estimated that not less than one-sixth of all the rocks on the surface of the earth are lime-stones, and that the element Calcium composes about one-sixteenth of the solid crust of the earth. From this it will be gathered that lime is sufficiently diffused in nature to supply the needs of most plants for this food. Indeed there are few arable soils so poor in lime as not to contain far more than would supply all the demands of crops for years; yet it may happen that in some sandy regions, and in soils that have resulted from the decomposition of certain substances, slates and other rocks poor in lime that there would be a deficiency of lime for serving as nourishment for plants; but in such cases the deficiency of other plant food would be more marked, and in supplying them from the sources ordinarily available the lime would be supplied in abundance for the food requirements of the crops.

The action of lime on soils may be summed up under three heads: 1st., Chemical action: 2nd., Physical action: and 3rd., as supplying a plant food. It is the first and second divisions only that have much importance for the Maryland farmer. Lime is termed an indirect fertilizer in consequence of the little need of it as a plant food, and because of its benefits being derived from its chemical and physical action on the soil. Different kinds of lime have, in the main, much the same kind of action, but they differ in the degree and avidity of the action.

### CHEMICAL ACTION OF LIME ON SOILS.

One of the most important chemical changes brought about in a soil through the action of lime is the decomposition of minerals, particularly the disintegration of refractory silicates. Such action as this would generally be produced more easily by caustic or quick-lime than by any other form. Lime materially aids in the formation of double silicates of alumnia, which have an important influence on the fertility of the land. Double silicates of alumina may be described as silicates of alumina in which part of the alumina is replaced by lime, soda, potash or ammonia. Most farmers are aware that ammonia is more valuable than potash, whilst potash is more valuable than soda and soda is more valuable than lime. The double silicates of alumina, when once formed, seem to recognize this, and exercise a similar order of preference. If a double silicate of alumina and lime exist in the soil and should be brought in contact with soda, some of the lime will be given up and soda will replace it, resulting in a silicate of alumina and soda. The presence of the lime will not enable it to replace the soda, as the silicate of alumina prefers the soda to the lime. If, however, potash be added, the soda is given up and potash taken into the combination, because the silicate of alumina prefers the potash. But if ammonia comes within the influence of this compound it will replace either the lime, soda or potash, and silicate of alumina and ammonia would be formed. These double silicates are in such shape as to be lost from the soil by leaching, yet are in a readily available condition for plants. From this it will be seen that it is desirable to promote the formation of double silicates, and caustic lime seems to have a decided action upon clays in starting and bringing about the formation of this most desirable class of bodies.

*Lime and Potash.*—Lime has not only the effect of aiding in the formation of unions of potash which will be held in the soil, but it also has the ability to liberate potash from combinations which are locked up and unavailable to plants. This is particularly marked when lime is applied to land containing fragments of feldspar. Gypsum is particularly useful in rendering potash available, and the sulphate of lime in dissolved phosphates often have an indirect value in this way.

Lime also favors the production of nitrate of potash in the soil. This is particularly true when lime is used on soils receiving considerable stable manure. The process and changes involved are axactly similar to those which have been employed in many places for the production of nitrate of potash (Nitre) for use in the manufacture of gunpowder, and for which a prize was awarded by the French Government to Mons. Thouvenel in 1776.

*Lime and Organic Compounds.*—Lime hastens the decomposition of organic matter and inert nitrogen compounds of humus in the soil, and promotes the formation of ammonia and nitrate compounds from the same. It also, as has been seen above, aids in the formation of compounds not easily rested from the soil. Lime promotes nitrifying ferments and makes possible their existence in many cases that would be impossible without its presence.

Lime produces particularly good results if applied after using green manuring, as it acts chemically and unites with some parts of the organic matter and leaves the remainder in a disorganized condition which rapidly decomposes. It is, perhaps, this tendency to destroy organic matter that makes the frequent use of lime pernicious. All evidence teaches us that lime is no substitute for manure but only a reinforcement of it. No doubt much land has been reduced to the verge of sterility by applying lime continually until all the organic matter has been used up. Such procedure is probably responsible for the old proverb, "Lime enriches the father but beggars the son."

*Lime and Phosphoric Acid.*—If a soil contains much phosphoric acid combined with iron and alumina which is relatively inert, an application of lime will change it into a form available to plants. Lime applied to soils which have received or will receive applications of dissolved phosphates, will not produce any harmful results or cause a loss of the phosphoric acid. It may hasten the reversion of the soluble phosphoric acid, but the phosphoric acid will still be in an available condition. In the average soil this reversion takes place in any case within twenty-four hours after applying the phosphate.

*Lime Corrects Acidity.*—Most cultivated soils possess a slightly acid reaction. This is generally due to decomposition of the remains of plants in the soil forming organic acids. On wet soils this condition is more noticeable than on dry soils. The sour humus and organic acids are not only unfavorable to the growth of nitrifying ferments and the root tubercles of leguminous plants but also are likely to dissolve iron and other compounds which are poisonous to microdemes and crops. Water-culture experiments have shown that slightly acid solutions are favorable to the growth of plants, and while most soils possess this character to slight degree, yet any excess of soluble acid in the soil would be highly detrimental. While most of our cultivated crops seem to need a slight acidity, it is probable that they have the ability to create this condition to a sufficient degree through the medium of the solutions sent out by their roots. This being the case, it would seem that the aim should be to keep soils in a neutral or slightly alkaline condition so as to favor the growth of root tubercles of the legumens and the desirable soil ferments.

Liming is excellent for correcting any excess of acidity, and is probably the most effective and economical substance for bringing about these other desirable conditions.

## PHYSICAL RESULTS OF LIMING SOILS.

The many chemical changes brought about by the action of lime on soils result in producing physical changes which give soils new mechanical characteristics. Lime has the power of changing the physical properties of a clay soil and making it more friable and easily cultivated, and putting it in a condition so that water may pass more freely through it. This will make it less susceptible to extremes of dry or wet weather, and make it a good home for the roots of the plants. The action of lime on sandy soils may be said to be the reverse of that on clay soils: that is it has a cementing action, making such soils stick together and in such a condition that they will hold more water and not dry out so rapidly.

These changes are brought about by what is termed the "flocculation" of the clay and organic particles. It has been found that one (1) part of lime has the power to flocculate and clear 10,000 parts of a turbid liquid, so that it can be readily understood that an application of one ton (25 bushels) of lime would have marked effect on an average soil to the depth of six inches which weighs approximately 900 tons.

## OTHER EFFECTS OF LIME.

As has been stated, applications of lime produce a beneficial effect in giving a favorable medium for the growth of nitrifying organisms and of the root tubercles on the leguminous plants (particularly the clover). Lime is also sometimes applied to prevent the "Club-foot" of certain root crops. It is sometimes used to destroy lavae, slugs and worms, but experiments do not bear this out and it is doubtful if it has such an effect. Applications of lime are also supposed to favor the development of certain injurious and undesirable conditions such as the scab disease in potatoes.

## EFFECTS OF LIME ON VARIOUS PLANTS.

The experiments conducted by the Rhode Island Experiment Station have resulted in the following classification of plants according to their action with reference to lime:

### TABLE I

*Giving approximate Effects of Lime on various Plants.*

| Plants benefitted by Lime | Plants indifferent to lime. | Plants injured by lime. |
|---|---|---|
| Spinach, | *Corn. | Watermelon, |
| Lettuce, | Millet | Serradella, |
| Beets, | Hungarian Millet, | Blue Lupine, |
| Okra | Golden " | Sheep Sorrel. |
| Salsify, | Rye, | |
| Celery, | Potatoes, | |
| Onions, | Carrots, | |
| Parsnips, | R. I. Bent Grass, | |
| Cauliflower, | Red top Grass, | |
| Cabbage, | | |
| Cucumbers, | | |
| Egg Plants, | | |
| Cantaloupes, | | |
| Agparagus, | | |
| Kohl-radi, | | |
| Dandelion, | | |
| Sweedish Turnip, | | |
| Pepper, | | |
| Pea, | | |
| Peanuts, | | |
| Martynia, | | |
| Tobacco, | | |
| Sorghum, | | |
| Alfalfa, | | |
| Clover, | | |
| Barley, | | |
| Wheat, | | |
| Oats, | | |
| Timothy, | | |
| Ky. Blue Grass, | | |
| Seed Fruits, | | |
| Stone Fruits. | | |

*Experiments at this Station have shown applications of lime to corn to give marked increase in yield.

## TIME OF THE YEAR TO APPLY LIME.

The fall is generally considered the best time to apply lime, but moderate application may be made at most any time the farmer finds it convenient to perform the work. With the conditions generally prevailing in this State it will usually be found most convenient to haul the lime in the winter and apply it in the spring in order to get it harrowed into the land. Much of the fall grain seed is put on corn ground and this land is not plowed up or in shape to apply the lime conveniently at that season.

It will be noted that most of the experiments reported in this bulletin are with a spring application.

## HOW MUCH AND HOW OFTEN TO APPLY THE LIME.

The quantity of lime applied varies considerably in the various sections and at various times. This has probably been due in a large measure to the cost of lime: but more recent observations seem to indicate that it is better to apply small quantities and make the applications at frequent intervals rather than apply very large quantities at one time. The old practice of putting 100 bushels or more per acre is seldom practiced now. The kind of soil to which the application is made makes it necessary to vary the quantity. It is now pretty well recognized that on poor soils and on sandy soils, the quantity applied at one time should be small. The quantity and frequency are points that are under test at this Station, and will be discussed in reporting results hereafter.

## METHOD OF APPLYING LIME.

There is probably considerable energy wasted and money lost in the manner in which lime is applied.

In the first place it should be remembered that the tendency of lime is downward in the soil, so it should always be applied at the surface and never plowed under. In the second place it should be remembered that the lime, when in its caustic or quick state, has the most power in producing chemical and physical changes in the soil. For this reason the aim should be to get the lime into the soil in its active state, and have it thoroughly incorporated in the soil before it has had a chance to lose any of its active principles. With this idea in mind, lime should be slacked by means of water, and, as soon as in a powdery state, should be spread over the land and at once harrowed in, to thoroughly incorporate it in the soil. Lime should not be allowed to "*air*" slake, as by so doing it absorbs carbonic acid from the air and is changed back to the carbonate, the form in which it existed before burning and consequently some of that which was paid for in burning is lost. Lime put on small or large piles to slake should be covered with earth to keep it out of contact with the air while slaking, and, as soon as it has come to a powdery condition, it should be spread on the land and harrowed in.

It will generally be found more economical to haul water to apply to the llme and slake it out at once rather than cover with earth. Slacking with water would be a more economical method than to lose part of the value of the lime through air slaking,

Do not apply lime on top of the land with the idea that the rains will dissolve it and carry it into the soil, for, in the first place the rains may not come until after some lapse of time and much of the lime will have returned to the carbonate; and, in the second place, it takes 700 pounds of water to dissolve one pound of lime and that amount of rain could not be depended upon.

Recently lime has been put on the market in a powdered caustic state so that it can be applied to the land with a grain drill or lime-spreader and get it thoroughly incorporated with the soil while it is still in the quick state which, theoretically, should be the best way. This kind of lime also affords an opportunity to apply small quantities and get it more evenly distributed than is possible with a shovel.

## HOW TO DETERMINE THE NEED FOR LIME.

There have been numerous methods proposed for determining the need for lime and the probable quantity required; none of them are very reliable and all take more or less skill in their application. The most reliable test is evidenced by the crop, but this takes considerable time. Probably the easiest test is the use of blue litmus paper* for testing the acidity of soils, and if it turns red rapidly it will generally indicate the need for lime. The blue litmus paper test is very simple; it is made by bringing a piece of blue litmus paper in contact with the moistened soil and observing the intensity and rapidity of the redness thus produced.

The general characteristics of the land as to its derivation can not be taken as a sure indication of the lack or supply of lime. It is not infrequent to find that in lime-stone regions and on the so-called lime-stone soils that applications of lime produce most marked results. This is due to the fact that the lime of lime-stone soils has been removed in a great part through prolonged decay and the dissolving action of the carbonated waters. This, not infrequently, leaves such soils so siliceous or ferrugenous as to be quite barren, and of a nature to be benefited by an application of lime. Throughout the areas occupied by the Trenton Limestones in Maryland, nearly every farm has, in years past, had its quarry and lime-kiln for fitting and supplying lime once more to soils that had been so thoroughly leached as to render them lean and poor.

## THE OCCURRENCE AND COMPOSITION OF THE SOURCES OF LIME IN MARYLAND.

Maryland is well supplied with lime for agricultural purposes. It is not only abundant, but quite generally and widely distributed.

The source of lime in Maryland may be divided into three general classes: first, lime-stones: second, marls: and third, shells. The lime-stones occur widely distributed throughout the western part of the State, and the marls throughout the tide-water areas of Southern Maryland and the Eastern Shore. The shell, derived mostly from the Oyster, is burned into lime and used more or less in all parts of the State, but most generally in the tide-water sections.

The occurrence of lime in this State is shown by Maps I and II, (accompanying this bulletin) giving the character and location of the deposits of marble and lime-stone in Maryland. These maps were prepared by the Maryland Geological Survey, and procured by us through the courtesy of Dr. Wm. B. Clark, State Geologist, who also furnished us with samples representing these various lime-stone deposits. These samples, 86 in number, are fairly representative in character, of the various geological formations, and their composition will be a much truer index of what could be expected in a given area than the selected samples sent for analysis by

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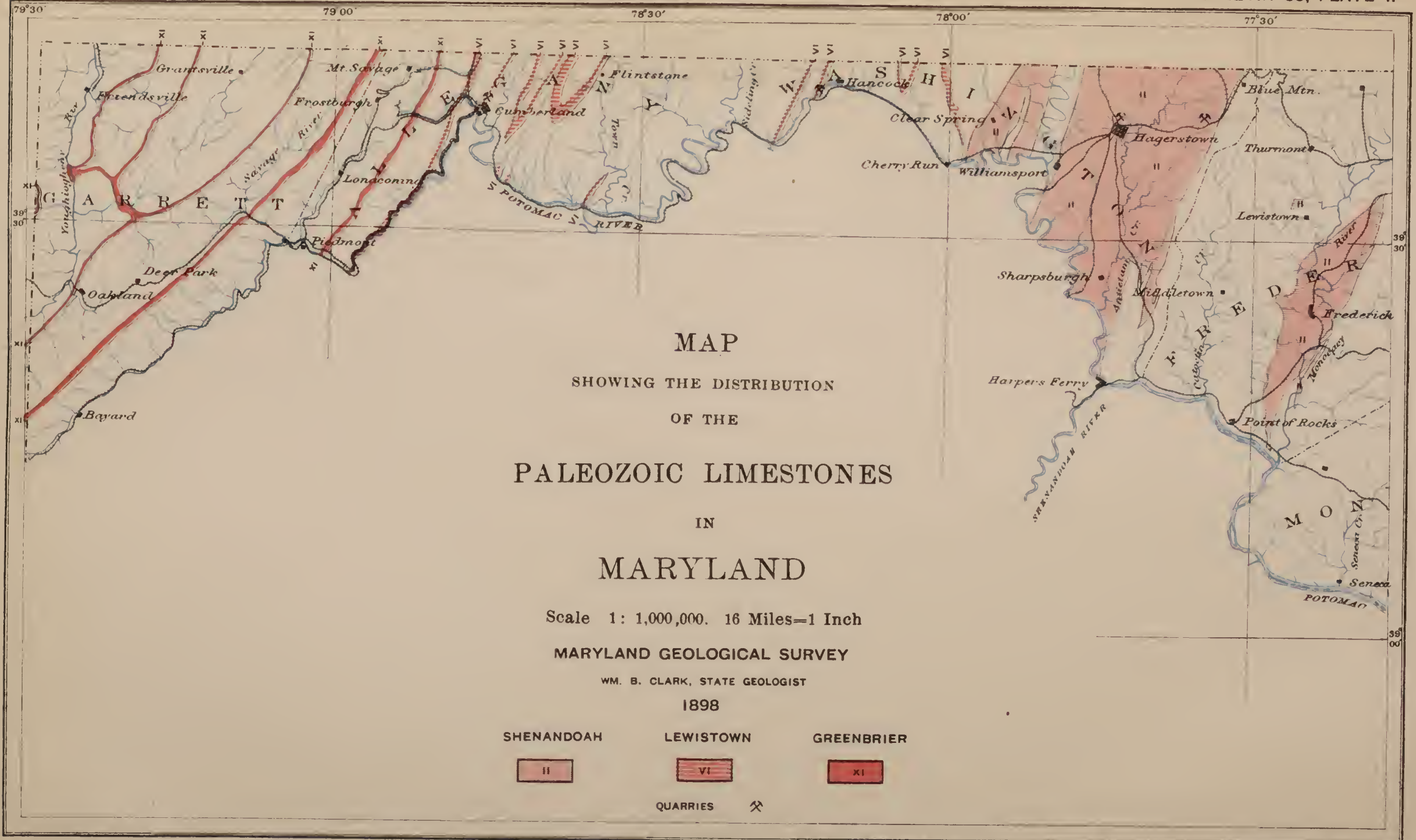
*This can be gotten at any drug store.



# MAP
SHOWING THE DISTRIBUTION
OF THE
# PALEOZOIC LIMESTONES
IN
# MARYLAND

Scale 1: 1,000,000. 16 Miles=1 Inch

MARYLAND GEOLOGICAL SURVEY

WM. B. CLARK, STATE GEOLOGIST

1898

| SHENANDOAH | LEWISTOWN | GREENBRIER |
|---|---|---|
| II | VI | XI |

QUARRIES ⚒

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many of the manufacturers of lime. The details of the analyses of the samples furnishsd by the Geological Survey were performed by Mr. Thomas Malcolm Price, Assistant Chemist of this Experiment Station. The description of these samples, as to Geological classification and locality, is given in the following pages. A more detailed report on these deposits from the Geological standpoint, will be made in the future through the reports of the Survey.

In addition to the report on the analyses of the samples furnished by the Survey, will be given the analyses of those that have come to this Station from time to time during the past twelve years. These samples, in some instances, have been sent by the manufacturers and in others by the users of the lime, hence the Station can only report on the quality of the sample received, and can, in no degree, vouch for the authenticity, of the sample.

In addition to the above will be given a compilation of a few of the analyses of the Maryland limes and lime-stones which have come to our attention. By referring to Maps I and II and comparing the analyses as given in the tables, it will be seen that limestone of good quality for agricultural purposes occur quite widely and generally distributed in Maryland, which, together with the marls and abundance of oyster shells in the bay and tide water sections, puts lime within easy reach of all. The variation in the quality of limestones in this State makes it possible to procure any grade desired, and where special advantages are obtained on some soils through the use of pure lime, magnesium lime or alum lime, they can be taken advantage of, and all at about the same price. A study of the quality of these various deposits makes it evident that where the simple effect of the lime is desired, that it could be obtained by using some of the local sources of lime and thus save much that is now being paid for freight in transporting lime from a relatively distant quarry.

There are few states where the farmers are so fortunate as to have some source of lime at almost every door, and there is no doubt but that it could be used advantageously by many, if applied judiciously.

## TABLE II.

*Description and Composition of Samples of Limestone furnished by the Maryland Geological Survey.*

T. MALCOLM PRICE, Analyst.

(Figures indicate per cents, or pounds in 100 pounds )

| Laboratory No. | Survey No. | Geological Classification | Locality. | Insoluble matter, sand silica, etc. | Iron and Aluminium Oxides. | Calcium (lime) Carbonate ($CaCO_3$) | Magnesium Carbonate ($MgCO_3$) | Total |
|---|---|---|---|---|---|---|---|---|
| 2140 | 8 | Archean | Carroll county........ ........ ....... ......... | 0.43 | 9.00 | 89.99 | 1.02 | 100.14 |
| 2141 | 4077 | Cambrian | Scaggs Quarry 1 mile west of Highlands, Howard county............... ...... | 48.39 | 14.24 | 35.66 | 1.96 | 100.25 |
| 2142 | 4078 | " | Wm. Federline's lime kiln; 1½ miles west of Highlands, Howard county | 10.13 | 10.94 | 75.67 | 3.70 | 100.34 |
| 2143 | 4642 | Carboniferous. | West of George's Creek; on the north side of Carlos Branch railroad, 3 miles south of Frostburg, Allegany county....................... ........ ......... ......... | 3.89 | 12.16 | 83.57 | 1.87 | 99.89 |
| 2144 | 4683 | " | West of Lonaconing near the Allegany-Garrett county line; 105 feet above the "Gib vein", Coal Mine, near the "Old Spring" at the new furnace shaft south of Koonts run . ..... .... | 4.37 | 19.62 | 74.70 | 2.01 | 98.69 |
| 2145 | 4685 | " | Mouth of stony Run, on the Potomac 2 miles east of Western Port, Allegany county.............................................. | 3.65 | 8.44 | 85.87 | 1.30 | 99.26 |
| 2146 | 4 | " | Gerrenger & Sugarhart's Quarry, near Friendsville, Garrett county............ | 13.65 | 5.44 | 79.16 | 1.21 | 99.46 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2147 | 4698 | " | On the west side of George's Creek & Cumberland Railroad; ½ mile west of Vale summit, in bed of ravine, Allegany county | 1.44 | 6.94 | 90.40 | 0.99 | 99.79 |
| 2148 | 4641 | " | From old opening on roadside; 1 mile north of Frostburg, near N. Y. Mine opening, Allegany county | 25.01 | 48.92 | 7.83 | 18.70 | 100.46 |
| 2149 | 3 | " | Offut's Quarry, 5 miles south west of Oakland, Garrett county | 13.46 | 12.48 | 72.92 | 1.15 | 99.91 |
| 2150 | 4693 | " | Mouth of Stony Run on the Potomac. 2 miles east of Western Port, Allegany county | 11.52 | 3.37 | 74.48 | 10.99 | 100.36 |
| 2151 | 4676 | " | In east bank of George's Creek, in town of Barton, Allegany county, only a few inches thick | 20.22 | 25.54 | 51.10 | 3.40 | 100.26 |
| 2152 | 4643 | " | Top stratum of lime stone in C. & P. R. R. cut; just south of crossing, near pumping shaft; 3 miles south of Frostburg, Allegany county | 10.63 | 13.18 | 73.73 | 1.61 | 99.15 |
| 2153 | 4715 | " | On Potomac Gravity Plain. 1½ miles east of Barton; about 80 feet above bottom of Fairfax formation, Allegany county | 9.86 | 4.90 | 83.69 | 1.96 | 100.41 |
| 2154 | 4709 | " | Near top of Fairfax formation; on W. S. Trimble's farm, south-east Mt Savage Station, Allegany county | 22.03 | 51.16 | 24.80 | 1.88 | 99.87 |
| 2155 | 2 | " | Lime kiln at Crabtree Station on B. & O. R. R. near Frankville, Garrett Co. | 8.57 | 2.38 | 88.73 | 0.86 | 100.51 |
| 2156 | 4667 | " | Mouth of Stony Run, on the Potomac. 2 miles east of Western Port, Allegany county | 5.11 | 3.56 | 89.08 | 3.17 | 99.92 |

TABLE II—*Continued.*

| Laboratory No. | Survey No. | Geological Classification | Locality. | Insoluble matter, sand silica, etc. | Iron and Aluminium Oxides. | Calcium (Lime) Carbonate $(CaCO_3)$ | Magnesium Carbonate $(MgCO_3)$ | Total |
|---|---|---|---|---|---|---|---|---|
| 2157 | 4928 | Chert Beds | North Branch, Allegany County.......... | 53.37 | 6.24 | 37.74 | 2.87 | 100.22 |
| 2158 | 7 | Cockeysville Marble | Cockeysville, Baltimore county............ | 9.79 | 5.62 | 70.64 | 14.61 | 100.60 |
| 2159 | 4629 | Devonian | 30 yards east of church on William's Road; about two miles east of Cumberland; 40 feet above the Romney-Monterey Contact.. ........................ | 30.37 | 61.62 | 5.19 | 2.80 | 99.98 |
| 2160 | 4639 | " | On county road, near spring on fork of road near south end of Warrior Mountain, west of Oldtown, Allegany county................ ....................... ...... | 89.80 | 2.16 | 7.14 | 1.07 | 100.17 |
| 2161 | 4723 | " | West side of W. Va. Cent R. R., in cut 20 yards north of Bridge across the Potomac. About 1 mile north of Keyser W. Va., but in Allegany Co.. | 21.78 | 4.30 | 69.08 | 3.81 | 98.97 |
| 2162 | 3036 | Greenbriar | Barrelville, Washington county.......... | 5.24 | 1.98 | 84.58 | 7.49 | 99.29 |
| 2163 | 35 | " | South of Negro Mountain, Garrett Co. | 20.95 | 41.10 | 37.35 | 0.91 | 100.36 |
| 2164 | 4103 | " | Offut's Quarry; 6 miles north of Oakland, Garrett county....................... | 17.00 | 2.74 | 62.12 | 15.75 | 99.61 |
| 2165 | 8000 | " | Findley's Quarry, Piney Run, Garrett county.......................... ....... .............. | 4.47 | 2.70 | 93.09 | 6.38 | 100.28 |
| 2166 | 3057 | Lewistown | Cumberland, Allegany county. ............ | 3.51 | 3.30 | 90.48 | 2.37 | 99.60 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2167 | 3055 | " | Miller's Quarry, Allegany county.. ..... | 1.83 | 2.40 | 92.96 | 2.83 | 100.02 |
| 2168 | 3059 | " | Mrs. M. Rowan........................ | 3.47 | 2.64 | 88.85 | 4.36 | 99.32 |
| 2169 | 3058 | " | C. F. Thrasher ........................ | 3.75 | 2.58 | 82.41 | 11.01 | 99.75 |
| 2170 | 4110 | " | Hancock, Washington county. ........... | 5.97 | 12.94 | 79.42 | 1.13 | 99.46 |
| 2171 | 9 | " | Pinto, Allegany county.......... .... ..... | 20.90 | 33.14 | 36.96 | 8.62 | 99.62 |
| 2172 | 10 | " | " " " ..................... | 17.91 | 6.14 | 73.13 | 2.48 | 99.66 |
| 2173 | 11 | " | " " " ...... ............... | 34.01 | 5.60 | 59.03 | 1.81 | 100.45 |
| 2174 | 3 | " | Clement vein No. 3 Clement Works, Pinto. Allegany county.. ................ | 26.43 | 8.18 | 52.35 | 12.81 | 99.79 |
| 2175 | 4 | " | Near top layer at Rawlins kiln, Potomac, W. Va. ................................ | 1.20 | 3.60 | 90.69 | 4.69 | 100.18 |
| 2176 | 4154 | " | Flintstone, Allegany county. ........ ..... | 5.57 | 4.43 | 84.32 | 5.93 | 100.25 |
| 2177 | 4914 | " | Cut in B. & O. R R. at Clement Mill Pinto, Allegany county.................. | 14.50 | 4.40 | 79.41 | 1.02 | 99.33 |
| 2178 | 5 | " | Potamac Station, Allegany county...... | 16.33 | 14.48 | 62.64 | 6.17 | 99.52 |
| 2179 | 2 | Monterey | Limey layers near top of Oriskay S. S., Cumberland Allegany county.......... | 57.49 | 4.40 | 26.88 | 10.79 | 99.56 |
| 2180 | 7095 | Newark | Lime stone *breccia,* Tyson's Quarry, Mt. Pleasant, Frederick county......... | 5.75 | 8.74 | 76.78 | 9.15 | 100.42 |
| 2181 | 4645 | Permian | On east side of Cumberland & Pa. R. R.; about 250 yards north of Frost burg, Allegany county .... .............. | 32.41 | 11.32 | 53.42 | 2.33 | 99.48 |
| 2182 | 4139 | Shenando'h | Cavetown, Washington county............ | 12.00 | 4.42 | 83.10 | 0.93 | 100.45 |

TABLE II—*Continued.*

| Laboratory No. | Survey No. | Geological Classification. | Locality. | Insoluble matter, sand Silica, etc. | Iron and Aluminium Oxides. | Calcium (Lime) Carbonate ($CaCO_3$) | Magnesium Carbonate ($MgCO_3$) | Total |
|---|---|---|---|---|---|---|---|---|
| 2183 | 4151 | Shenandoah | Sharpsburg, Washington County ......... | 0.70 | 2.84 | 91.32 | 5.05 | 99.91 |
| 2184 | 6 | " | Leitersburg, Washington county ......... | 3.53 | 3.42 | 90.01 | 2.13 | 99.69 |
| 2185 | 3056 | " | Leopold's Quarry ............................. | 1.51 | 5.90 | 89.07 | 3.25 | 99.73 |
| 2186 | 4145 | " | North edge of Flintstone, Washington county ................................ | 21.84 | 12.08 | 64.33 | 1.76 | 100.01 |
| 2187 | 1 | " | Keedysville, Washington county ......... | 0.63 | 6.30 | 90.92 | 2.49 | 100 34 |
| 2189 | 4150 | " | On C. & O. Cent. Canal; 4 miles south of Sharpsburg, Washington county... | 2.14 | 6.70 | 89.82 | 1.10 | 99.76 |
| 2188 | 4127 | " | South east of Leitersburg on road near creek ..................................... | 4.17 | 8.04 | 81.73 | 6.62 | 99.56 |
| 2190 | 4141 | " | Cavetown, Washington county ........... | 20.32 | 8.60 | 66.80 | 3.36 | 99.08 |
| 2191 | 7006 | " | Cramer's Quarry, Mt. Pleasant, Frederick county........................................ | 11.13 | 8.00 | 78.62 | 2.60 | 100.05 |
| 2192 | 7115 | " | Mountview, Frederick county.. ... ...... | 4.99 | 6.28 | 84.14 | 3.97 | 99.38 |
| 2193 | 7104 | " | C J. Keller's Quarry, Buckstown, Frederick county.................................. | 33.36 | 6.65 | 57.41 | 3.02 | 100.39 |
| 2194 | 7070 | " | Union Bridge, Carroll county ............. | 0.56 | 1.50 | 97.14 | 0.81 | 100.01 |
| 2195 | 7071 | " | " " " ............ | 0.50 | 2.94 | 95.44 | 1.33 | 100.21 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2196 | 7073 | " | " " " ............ | 0.43 | 4.28 | 94.10 | 1.64 | 100.45 |
| 2197 | 7102 | " | Frederick City, Frederick county......... | 1.65 | 3.26 | 90.23 | 5.19 | 100.33 |
| 2198 | 7021 | " | H. Cramer's Quarry, Mt. Pleasant, Frederick county.............................. | 9.06 | 10.92 | 78.56 | 2.07 | 100.61 |
| 2199 | 7108 | " | D. Roddy's Quarry, Thurmont, Fredrick county.................................... | 0.52 | 4.54 | 92.67 | 1.80 | 99.53 |
| 2200 | 7106 | " | D. Roddy's Quarry. Thurmont, Frederick county.................................. | 5.66 | 0.74 | 93.05 | 1.84 | 101.29 |
| 2201 | 7102 | " | Mountview, Frederick, Frederick Co.... | 4.64 | 0.14 | 93.14 | 1.39 | 99.31 |
| 2202 | 4199 | " | Yost's Quarry. west of Hagerstown, Washington county.......................... | 4.99 | 0.44 | 91.03 | 3.28 | 99.74 |
| 2203 | 4180 | " | Deitrich Quarry, west of Hagerstown, Washington county.......................... | 9.46 | 4.04 | 62.10 | 4.63 | 99.37 |
| 2224 | 7098 | " | Barrett's Quarry, Woodboro, Frederick county........................................ | 2.33 | 10.10 | 81.57 | 5.60 | 99.60 |
| 2225 | 3056 | " | Leopold's Lime Kiln. This is a duplicate in number and description to No. 2185, but different in appearance | 1.93 | 5.66 | 83.35 | 8.50 | 99.44 |
| 2204 | 4175 | Upper Silurian. | A small lime kiln on National road, 4 miles northeast of Cumberland, Allegany county,.................................. | 0.75 | 0.16 | 92.19 | 7.38 | 100.38 |
| 2205 | 4618 | Top of Silurian | Near the canal at South end of Nicholas mountain; at the Louistown-Monterey contact, Allegany Co........ | 10.68 | 6.98 | 79.89 | 2.82 | 100.35 |
| 2206 | 4125 | Silurian | Murray lime kiln; 2½ miles west of Hancock, near the National road...... | 12.38 | 3.30 | 83.59 | 0.69 | 99.97 |

TABLE II—*Continued*.

| Laboratory No. | Survey No. | Geological Classification. | Locality. | Insoluble matter, sand silica, etc. | Iron and Aluminium Oxides. | Calcium (Lime) Carbonate ($CaCO_3$) | Magnesium Carbonate ($MgCO_3$) | Total |
|---|---|---|---|---|---|---|---|---|
| 2207 | 4153 | Silurian | Western Maryland Railroad Quarry; 2½ miles west of Williams Port, Washington county. | 4.04 | 9.80 | 77.10 | 8.38 | 99.22 |
| 2208 | 4128 | " | On roadside near Leitersburg, Washington county. | 5.42 | 4.20 | 89.61 | 0.07 | 99.30 |
| 2209 | 4143 | " | North suburbs of Funkstown, Washington county | 0.62 | 8.08 | 85.82 | 5.88 | 100.40 |
| 2210 | 4131 | " | Roadside near Leitersburg, Washington county | 4.08 | 4.70 | 82.03 | 9.71 | 100.52 |
| 2211 | 4111 | " | At side of National Road, in western suburbs of Hancock Washington county | 3.80 | 4.00 | 89.53 | 2.42 | 99.75 |
| 2212 | 4155 | " | Yost's Quarry, about 5 miles west-northwest of Hagerstown Washington county | 0.80 | 4.64 | 92.19 | 2.84 | 100.47 |
| 2213 | 4504 | " | From out crop on National road in eastern suburbs of Flintstone, Allegany county | 1.88 | 5.98 | 89.64 | 2.42 | 99.72 |
| 2214 | 4148 | " | Near C. & O. Canal; 4 miles south of Sharpsburg, Washington county | 1.79 | 3.46 | 83.33 | 11.50 | 100.08 |
| 2215 | 4177 | " | Byer's Quarry. in northern suburbs of Hagerstown, Washington county | 3.65 | 4.44 | 91.92 | 0.25 | 100.08 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2216 | 4179 | " | Yost's Quarry, (?) miles west of Hagerstown | 2.39 | 1.47 | 92.74 | 2.57 | 99.17 |
| 2217 | 1 | " | Mullen's lime kiln, in northeast part of Cumberland, Allegany county | 12.27 | 12.88 | 73.46 | 0.86 | 99.47 |
| 2218 | 4154 | " | So Called "Black Marble". 1½ miles south of Flintstone, Allegany county | 5.92 | 12.98 | 79.92 | 0.36 | 99.18 |
| 2219 | 4500 | " | East side of Flintstone Creek ¼ mile north of Flintstone Allegany county. | 7.33 | 9.18 | 83.60 | 0.22 | 100.33 |
| 2220 | 4152 | " | Railroad cut, 2 miles north of Keedysville, Washington county | 3.21 | 4.12 | 91.85 | 0.74 | 99.92 |
| 2221 | 4180 | " | Dietrick's Quarry; (?) miles west of Hagerstown, Washington county | 11.00 | 8.20 | 77.51 | 3.25 | 99.96 |
| 2222 | 4140 | " | Limestone Quarry in Cavetown, Washington county | 0.74 | 6.98 | 91.01 | 0.74 | 99.47 |
| 2223 | 3065 | Spencer | Pinto, Allegany County | 0.79 | 9.03 | 87.03 | 2.60 | 99.35 |

## TABLE III.

*Description and Composition of Miscellaneous samples of Limestone sent to the Experiment Station for Analysis.*

H. J. PATTERSON, Analyst.

(Figures indicate Per cents, or pounds in 100 pounds.)

| Laboratory No. | Description of Sample. | Sent by: | Insoluble matter, sand, silica, etc. | Iron and Aluminium Oxides. | Calcium (lime) Carbonate, $CaCO_3$. | Magnesium Carbonate, ($MgCO_3$) | Undetermined | Total. |
|---|---|---|---|---|---|---|---|---|
| 802 | Gray Limestone....... ........ | M. J. Grove Lime Co., Lime Kiln, Maryland .......... | 0.31 | 0.14 | 93.49 | 5.95 | ..... | 99.99 |
| 803 | Blue Limestone...... ....... | M. J Grove Lime Co., Lime Kiln, Maryland.......... | 3.90 | 0.36 | 93.26 | 2.50 | ...... | 100.02 |
| 1042 | Pulverized Marble....... .. | Beaver Dan Marble Co., Cockeysville, Maryland....... | 2.33 | 1.55 | 52.33 | 43.69 | 0.08* | 99.98 |
| 1542 | Limestone................ ...... | E. H. Brown, Johnsville, Md......... | 7.15 | 11.90 | 51.61 | 27.45 | 1.89‡ | 100.00 |
| 1563 | Micaceous Gray Limestone. | Mrs. Hopkins, Highlands, Md........ | 13.60 | 5.15 | 77.82 | 3.19 | 0.24‡ | 100.00 |
| 1565 | Limestone........... .... .... | E. W. Adams, Clarksville. Md ...... | 13.00 | 6.00 | 50.00 | 31.00 | ...... | 100.00 |
| 1567 | Limestone ................ | T. T. Hershberger, Frederick, Md.. | 10.17 | 5.53 | 78.12 | 6.18 | ...... | 100.00 |
| 1879 | Mixture of blue, dark gray and light-gray stone. .. | J W. LeGore, Woodsboro, Maryland.... | 0.50 | 0.60 | 98.39 | 0.51 | ...... | 100.00 |
| 1991 | Gray Limestone ......... ..... | Aaron Wood, Woodsboro. Md........ | 5.30 | 9.80 | 53.57 | 31.33 | ...... | 100.00 |
| 2116 | Limestone......... ....... | J. N. Clery, Frederick, Md............ | 62.40 | 7.60 | 30.00 | 0.00 | ...... | 100.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2122 | Lightest-gray Limestone.... | J. W. Stimmel, Walkersville, Md.. | 4.73 | 1.40 | 93.51 | 0.30 | 0.06 | 100.00 |
| 2123 | Gray Limestone................ | J. W. Stimmel, Walkersville, Md.. | 4.31 | 0.90 | 81.79 | 13.00 | ..... | 100.00 |
| 2127 | White Limestone.............. | Kerr Bros. Co., Wrightsville, Pa.... | 0.49 | 1.80 | 94.53 | 3.18 | ...... | 100.00 |
| 2128 | Gray Limestone................ | Kerr Bros. Co., Wrightsville, Pa.... | 0.26 | 3.10 | 93.32 | 3.32 | .... | 100.00 |
| 2226 | Gray Limestone............... | Joshua C. Miller, Boonsboro. Md.... | 1.26 | 10.63 | 88.07 | 0.00 | 0.07 | 100.00 |
| 2227 | White Limestone ............ | Joshua C Miller, Boonsboro, Md.... | 1.95 | 9.92 | 83.39 | 3.19 | 0.55 | 100.00 |
| 46 | Oyster Shells...................... | Sample analyzed by J. R. Laughlin | 1.15 | 1.00 | 94.75 | 0.00 | 2.44† | |
| 47 | " ".......... .......... | " " " | 1.12 | 1.31 | 92.94 | 0.00 | 3.79† | |

*Water in the marble dust. ‡Potash calculated as $K_2O$.

†Water—These samples had 0.10 and 0.24 per cent phos-phoric acid, respectively.

## TABLE IV.

*Composition of Miscellaneous Samples of Maryland Limestone.*

(Analyses procured from various sources).

(Figures indicate Per cents, or pounds in 100 pounds.)

| Description of Sample | Analyst. | Insoluble matter, sand silica etc. | Iron and Aluminium Oxides. | Calcium (lime) Carbonate, $CaCO_3$ | Magnesium Carbonate, ($MgCO_3$) | Undetermined. | Total. |
|---|---|---|---|---|---|---|---|
| Cockeysville Marble.................. | Schneider.. | 5.57 | 0.40 | 51.90 | 42.60 | | 100.47 |
| Cockeysville Marble.................. | Whitefield.. | 0.44 | trace | 54.87 | 43.84 | | 99.15 |
| Cockeysville Marble.................. | Higgins..... | 2.33 | 0.00 | 52.33 | 43.70 | | 98.36 |
| Texas Limestone.................. | Williams.... | 2.00 | 0.00 | 93.00 | 5.00 | | 100.00 |
| Wash. Co., Limestone, from Dr. T. Maddox. | Dr. Higgins. | 5.80 | 0.10 | 90.70 | 3.18 | 0.12 | |
| " " " " | " | 0.60 | 0.00 | 98.53 | 0.87 | 0.00 | |
| " " " David Zellers. | " | 0.25 | ...... | 96.75 | 2.75 | 0.25 | |
| " " " B. J. Beyers. | " | 2.40 | 0.60 | 94.76 | 2.25 | trace | |
| " " " I. E. Davis..... | " | 3.00 | 0.27 | 53.94 | 42.79 | trace | |
| " " " " ..... | " | 0.70 | 0 00 | 54.93 | 44.35 | trace | |
| " " " George Heyser.. | " | 2.00 | 0.30 | 95.00 | 2.60 | 0.10 | |
| " " " John T. Mason. | " | 2.00 | 0.64 | 56.50 | 30.80 | 0.00 | |
| " " " James Biays...... | " | 0.60 | 0.00 | 98.53 | 0.87 | 0.00 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Specimen from head of Pleasant Valley ....... | “ | 6.00 | 0.20 | 90.70 | 3.00 | 0.00 |
| “ “ Beaver Creek......... ......... | “ | 0.20 | 0.10 | 97 00 | 2.50 | 0.30 |
| “ “ near Williamsport. ......... | “ | 0.50 | 0.10 | 98.50 | 0.80 | 0.10 |
| “ “ Carroll County: | | | | | | |
| White limestone from Unionville.......... ...... | “ | 0.50 | ..... | 99.50 | 0.00 | ...... |
| Dark gray Limestone from Rinehart............. | “ | 20.20 | ...... | 68.30 | 11.50 | ...... |
| Dark-gray Limestone with white veins.......... | “ | 0.70 | ...... | 98.80 | 0.50 | ...... |

## TABLE V.

*Description and Composition of Miscellaneous Samples of Burned (Quick) Lime, Sent to the Experiment Station for Analysis.*

H. J. PATTERSON, Analyst.

(Figures indicate per cent or Pounds in 100 pounds.)

| Laboratory No. | Description of Sample. | Sent by: | Insoluble matter | Iron and Aluminium Oxides. | Lime (CaO) | Magnesia (MgO) | Undetermined* | Total |
|---|---|---|---|---|---|---|---|---|
| 1043 | Woodsboro Lime ............ | W. H. Biggs & Bro., Ricky Ridge, Md. | 1.85 | 3.10 | 91.10 | 0.92 | 3.03 | 100.00 |
| 1044 | Cavetown Lime. ............ | " " " " ... | 2.75 | 4.83 | 73.90 | 17.94 | 0.58 | 100.00 |
| 1543 | | Adam Diehl, Jr., Walkerville, Md......... | 1.35 | 0.75 | 83.40 | 0.72 | 13.78 | 100.00 |
| 1723 | Oyster Shell Lime............ | Purchased in Baltimore City......... ... | ...... | ...... | 61.75 | ...... | ........ | ........ |
| 1724 | Stone Lime........................ | " " Silver Spring, Md.......... | ...... | ...... | 95.25 | ...... | ........ | ........ |
| 1725 | Gas house Lime............... | " " Baltimore City............... | ...... | ...... | 42.50 | ...... | ........ | ........ |
| 1732 | Wrightsville Lime............ | Edward Boynton, Port Deposit, Md..... | 0.15 | 1.50 | 67.44 | 30.91 | ........ | 100.00 |
| 1790 | Grove's Lime.................... | P. C. Prough, Freedom, Md................ | 25.00 | 2.40 | 47.10 | 25.16 | 0.34 | 100.00 |
| 1791 | Black's Lime.................... | " " " ............... | 19.71 | 7.00 | 69.80 | 2.02 | 1.47 | 100.00 |
| 1848 | LeGore's Combination Lime...................... | W. O. Thomas, Sudlersville, Md.......... | 1.63 | 1.20 | 96.00 | 1.08 | ....... | 100.00 |
| 1949 | Frederick City Lime Co's Lime........................ | Frederick City Lime Co., Frederick, Md. | 7.70 | 2.55 | 84.89 | 4.86 | ........ | 100.00 |
| 2019 | Aaron Wood's Lime......... | Aaron Wood, Woodsboro, Md............. | 1.06 | 2.40 | 90.00 | 1.00 | 4.54 | 100.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2130 | | Benjamin F. Rash, Worton, Md ........ | 6.69 | 9.30 | 82.00 | 0.40 | 1.61 | 100.00 |
| | Ground Stone Lime.......... | Maryland Agri. Experiment Station.... | 2.60 | 8.26 | 82.06 | 2.94 | 3.14 | 100.00 |
| | Glass-house Lime.............. | " " " " .... | 6.33 | 9.56 | 83.11 | 0.35 | 0.65 | 100.00 |
| | Howard County Lime....... | Dr. Tatum, Ashton, Md........................ | 6.02 | 13.30 | 75.40 | 2.00 | 3.28 | 100.00 |

*Mostly water and carbonic acid gas.

## TABLE VI.

*Description and Composition of Samples of Quick Lime.*

SAMPLED AND ANALYSED BY DR. H. B. MCDONNELL AND F. P. VEITCH.

(Figures indicate per cents, or pounds in 100 pounds.)

| Labortory No | Description of Sample. | Sample taken at | Insoluble matter, sand, silica etc | Iron and Aluminium Oxides. | Lime (CaO) | Magnesia (MgO) | Water and Carbon-dioxide. | Total. |
|---|---|---|---|---|---|---|---|---|
| 1 | Gas lime, Fresh.......... .... | Canton, Baltimore County, Md.......... | 8.54 | 2.15 | 42.44 | 0.34 | 44.94 | 100.00 |
| 2 | “ “ Weathered 1 year | “ “ “ .......... | 4.54 | 1.11 | 34.81 | 0.24 | 57.93 | 100.00 |
| 3 | “ “ Fresh .......... | “ “ “ .......... | 4.41 | 1.47 | 37.50 | 0.29 | 55.41 | 100.00 |
| 4 | “ “ “ .... ....... | Bayard Street, Baltimore, Md.... ....... | 8.20 | 1.66 | 41.60 | 0.33 | 46.89 | 100.00 |
| 5 | “ “ Weathered 10 years. | “ “ “ . ....... | 8.70 | 1.65 | 30 83 | 0.20 | 57.70 | 100.00 |
| 6 | Oyster Shell lime, slaked fresh................ ... | “ “ “ . ..... | 8.99 | 1.84 | 54.62 | 0.43 | 33.27 | 100.00 |
| 7 | Oyster shell lime, fresh burned................ | H. C. Pearson Packing Co., Baltimore, Md ....... ............ ......... . .. .. | 5.79 | 2.71 | 84.58 | 0.55 | 5 92 | 100.49 |
| 8 | Stone lime from Texas, Md. | Texas Lime Co.. Baltimore, Md.......... | 3.32 | 1.09 | 86.17 | 5.82 | 3.42 | 100.00 |
| 9 | “ “ Crucible burned, Select ... ................ | Sent by the Standard Lime Co., from Engles, W. Va........................ | 0.22 | 0.44 | 98.06 | 0.50 | 0.67 | 100.00 |
| 10 | Stone lime from Frederick. | Washington Grove............. ............. | 18.96 | 3.14 | 69.18 | 15.77 | 2.95 | 100.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | " " " Lime Kiln | Boyds, Maryland | 11.65 | 2.80 | 62.34 | 19.69 | 3.52 | 100.00 |
| 12 | " " " Buckeystown | Mt. Airy, Woodbine and Derwood, Md | 12.08 | 2.95 | 74.4[illegible] | 9.70 | 1.27 | 100.45 |
| 13 | " " " LeGore | Legore | 6.27 | 1.86 | 87.09 | 4.39 | 0.81 | 100.42 |
| 14 | " " " Martinsburg, W. Va.* | Rockville and Sykesville, Md | 1.72 | 1.93 | 93.49 | 0.73 | 2.13 | 100.00 |
| 15 | Stone lime from Engles, W. Va* | Rockville and Germantown, Md | 12.71 | 2.20 | 67.16 | 16.83 | 2.13 | 101.03 |
| 16 | Stone lime from Buckeystown, Md | College Park, Md | 1.69 | 0.74 | 77.16 | 1.19 | 19.22 | 100.00 |

*Composite samples.

NOTE:—The gaslime contained, in addition to the above, small amounts of Sulphur, sulphuric acid, and phosphoric acid; and the Oyster-shell lime, small amounts of phosphoric acid. These have been added in to make the total.

## MARLS.

Marls are found in large quantities in many parts of Maryland; and have been used more or less for agricultural purposes for many years. From the small quantity of plant food which marls furnish, and the difficulty and expense of handling and transportation, their use is generally confined to places very near the deposits.

Marls may be considered in three classes, according to their general character and the geological formations in which they occur, being only three of the many formations in this State. These formations are found, as a rule, one above the other, but it is rare that more than one occurs in a single exposure. The upper marl known as shell marl or blue marl, is found in the Neocene or most recent of these formations, at or very near the surface. It consists chiefly of seamud, with sand and clay and partially decayed shells and bones. Its value depends mainly on lime, which it contains in the form of the carbonate. This class of marls usually has a very small percent of phosphoric acid and potash, although sometimes it contains beds of glauconite which gives a higher potash value. The physical character of these calareous marls varies with the class of animal remains from which they are derived, and the state of preservation of the same. To this class belong most of the marls that have been examined at this Station, as this Neocene formation covers a large area in Southern Maryland.

The second class of marls is found in the Eocene formation, which is older than the Neocene and is just below it in the Geological order. It is friable and somewhat chalky, consisting of comminuted shells and corals, and is of a light color. The agricultural value of this variety is given by the potash and the carbonate of lime which it furnishes. The glauconite or green sand may be expected to be found in this class. In parts of New Jersey this is very prominent, but the percentage of potash has been found, as a rule, to be much lower in this State.

The third class, or that which has the lowest Geological position is the Cretaceous marl. This also contains glauconite and is commonly known in New Jersey as "green sand". There are very few exposures of this formation in Maryland and it is difficult to distinguish it from the Eocene. Marls of this class vary considerably in their chemical composition and agricultural value. They owe their fertilizing quality to the presence of phosphoric acid and potash, and sometimes contain a goodly admixture of calcareous matter. The best New Jersey marls, and those that have been used with the most success, have contained from two to three percent of phosphoric acid and from five to seven percent of potash. The few Maryland marls of this class that have been examined here thus far, have not given nearly as high a per cent of these ingredients.

Marls occur in each of these three geological formations in a succession of beds, varying in thickness from a few inches to many feet, and separated by layers of gravel, sand or clay. There may be many of these beds of marl in the same formation, and several beds of the same class are often seen in the same exposure, but the different classes of marl are rarely seen together.

The potash of marls, being in an insoluble form must necessarily act very slowly in the soil. Much of the potash in marls will become slowly available to plants through weathering, but considerable of it could be rendered available by the action of lime, which probably takes place through the formation of the double silicates spoken of on page 95. This change could readily be brought about by burning those marls which contain considerable Calcium (lime) Carbonate, and then slaking the product. This could be performed with profit with some of the marl deposits of the State and give a cheap source of lime, at the same time furnishing some potash and phosphoric acid. Such applications would be highly beneficial to the lands on the farms in the neighborhood of such deposits.

The following table gives the results of the examination of ninety separate samples from various parts of this State. Many of these results are published here for the first time, and some of them were published in the Second, Third and Fourth Annual Reports of this Station. In these reports will be found more detailed description of the various marls than is given here. Many of the samples of marl examined have more than usual interest and value from the fact that they are highly representative of the various classes of deposits in the State, as they were carefully selected, described and classified, by Prof. Milton Whitney, Soil Physicist of the Station, during a geological expedition along the shores of the Chesapeake Bay and the Potomac and Patuxent Rivers in May 1891. Collectively, the samples reported upon in this bulletin are believed to represent in character and composition, all the deposits in Maryland which are so exposed as to be accessible for use.

## TABLE VII

*Description and Composition of Marls, sent to the Experiment Station for Analysis.*

H. J. PATTERSON, Analyst.

(Figures indicate per cents, or pounds in 100 pounds.)

| Laboratory No | Description and source of sample. | | Insoluble matter. | Lime (CaO) | Phosphoric acid $P_2O_5$ | Potash $K_2O$ |
|---|---|---|---|---|---|---|
| 35 | Upper layer 7 feet thick. | Sent by H. M. Murray, West River | 68.50 | 0.38 | 0.58 | 3.22 |
| 36 | Under No 35. 5 feet thick. | “ “ “ “ “ | 63.77 | 0.25 | 0.32 | 3.02 |
| 37 | Under No. 36, 40 feet thick. | “ “ “ “ “ | 68.45 | 0.25 | 0.34 | 3.52 |
| 38 | Deposit near Stream, | “ Richard Baldwin, Waterbury | 89.02 | ...... | 0.08 | 0.25 |
| 42 | Sand and shell marl, | “ Spear and Critcher, Glymont | 46.12 | 31.92 | 0.14 | 0.49 |
| 43 | “ “ “ | “ “ “ “ | 62.71 | 17.22 | 0.05 | 0.59 |
| 49 | Lime marl | “ Fred. Sasscer, Upper Marlboro | 70.76 | 0.23 | 0.58 | 2.37 |
| 50 | Shell marl | “ “ “ “ “ | 60.51 | 14.71 | 0.12 | 1.89 |
| 54 | Sand marl, | “ L. B. Johnson, Piscataway | 61.84 | 5.37 | 0.16 | 1.57 |
| 55 | “ “ | “ “ “ “ | 44.71 | 9.00 | 0.24 | 2.08 |
| 83 | Chalky marl, | “ Dr. Chas. Lowndes, Easton | 18.77 | 39.90 | 0.32 | 0.18 |
| 92 | Sand and shell marl, | “ Geo. Taylor, Glymont | 67.70 | 1.88 | 0.50 | 1.78 |
| 447 | Light brown shell marl. | “ J. A. Cunningham, Friendship | 77.82 | 8.56 | 0.44 | 0.84 |
| 448 | “ “ marl, | “ P. H. Prout, Friendship | 82.67 | 8.00 | 0.26 | 0.28 |
| 449 | Sand marl | “ J. A. Wood, “ | 92.23 | 1.06 | 0.88 | 0.59 |
| 450 | “ “ | “ “ “ “ | 92.19 | 1.00 | 0.52 | 0.23 |
| 451 | Shell marl, | “ “ “ “ | 76.62 | 11.19 | 0.89 | 0.22 |
| 452 | “ “ | “ “ “ “ | 80.28 | 9.50 | 0.14 | 0.42 |
| 453 | “ “ rock, | “ “ “ “ | 98.02 | ...... | ...... | ...... |
| 454 | | “ L. M. K. Griffith, Dunkirk | 83.37 | 4.25 | 1.74 | 0.44 |
| 455 | Shell marl. | “ “ “ “ | 84.96 | 0.56 | 0.12 | 0.52 |
| 456 | | “ “ “ “ | 81.86 | trace | 0.12 | 2.49 |
| 457 | | “ “ “ “ | 80.04 | “ | 0.30 | 2.40 |
| 459 | Shell marl rock, | “ “ “ “ | 96.96 | ...... | ...... | ...... |
| 461 | Shell marl | “ E. L. F. Hardcastle, Lee Haven | 38.39 | 28.37 | 0.22 | 0.43 |
| 462 | “ “ | “ “ “ “ “ | 26.21 | 31.94 | 0.30 | 0.32 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 536 | Light gray, partly decomposed | “ | T. F. Lansdale, Tridelphia | | trace | race | 0.25 |
| 537 | “ “ sandy appearance | “ | “ “ “ | | “ | “ | 0.26 |
| 585 | Shell marl, | “ | T. R Brooks, Seat Pleasant | 65.48 | 12 37 | 0.24 | 1.41 |
| 586 | Blue or green sand marl, | “ | “ “ “ “ | 76.11 | 4.38 | 0.30 | 1.84 |
| 587 | Shell marl | “ | “ “ “ “ | 69.37 | 9.88 | 0.16 | 1.62 |
| 588 | Shell marl, | “ | “ “ “ “ | 51.41 | 22.20 | 0.16 | 2.85 |
| 589 | “ “ | “ | “ “ “ “ | 64.54 | 12.37 | 0.12 | 1.39 |
| 590 | Brown sand marl, | “ | “ “ “ “ | 81.22 | 1.50 | 0.20 | 2.08 |
| 591 | Blue or green sand marl, | “ | “ “ “ “ | 81.84 | 1.00 | 0.20 | 1.71 |
| 592 | Shell marl, | “ | “ “ “ “ | 53.34 | 16.87 | 0.16 | 2.29 |
| 593 | Marl Rock, | “ | R. S. Mitchell, Glymont | 36.09 | 29.00 | 0.12 | 0.23 |
| 594 | White chalky marl, | “ | Dr. Chas. Lowndes, Easton | 13 21 | 45.88 | 0.16 | 0.24 |
| 605 | Marsh mud | “ | Thos. Hill, Baltimore | 87.57 | 1.38 | 0.12 | 0.23 |
| 606 | “ “ | “ | “ “ “ | 87.34 | 1.25 | 0.14 | 0.22 |
| 610 | Light gray marl, | “ | Dr. Chas. Tilghman, Tunis Mills | 57.58 | 20.90 | 0.40 | 0.29 |
| 611 | Dark “ “ | “ | “ “ “ “ “ | 74.00 | 13.12 | 0.28 | 0.38 |
| 612 | Muck, | “ | “ “ “ “ “ | 20.88 | trace | 0.28 | 0.69 |
| | | NEOCENE MARLS. | | | | | |
| 1026 | Shell marl | From | Jones' Wharf | 46.76 | 24.55 | 0.10 | 0.24 |
| 1025 | Under No. 1022 | “ | Cove Point | 67.24 | 15.30 | 0.06 | 1.88 |
| 1027 | Shell marl | “ | Plum Point | 71.43 | 13.70 | 0.38 | 0.72 |
| 1021 | “ “ | “ | “ “ | 73.08 | 12.45 | 0.38 | 0 31 |
| 1022 | Yellowish-green marl | “ | Cove Point | 73.07 | 12.15 | 0.06 | 0.33 |
| | | EOCENE MARLS. | | | | | |
| 1107 | Shell marl | From | Bel Alton | 65.51 | 1.25 | 0.26 | 4.76 |
| 1106 | Shell marl, under No. 1107 | “ | “ “ | 67.68 | 5.10 | 0.29 | 4.17 |
| 1108 | | “ | “ “ | 80.94 | 0.85 | 0.45 | 0.73 |
| 1167 | Green sand marl | “ | Upper Marlboro | 75.33 | 0.45 | 0.45 | 2.88 |
| 1030 | “ “ “ | “ | Donaldsonville | 80.11 | 0.30 | trace | 2.71 |
| 1019 | Shell marl, under No. 1029, | “ | Clifton Beach | 52 93 | 12.70 | 0.20 | 2.36 |
| 1028 | Green-Sand and shell marl, | “ | Pope's Creek | 78.25 | trace | trace | 2.35 |
| 1105 | Shell Marl, | “ | Bel Alton | 66.00 | 5.90 | 0.24 | 2.34 |
| 1079 | Green sand Marl, | “ | Mathias Point, Va. | 78.66 | trace | trace | 1.81 |
| 1023 | Shell marl, | “ | Clifton Beach | 59 85 | 11.45 | 0.16 | 1.11 |
| 1024 | Green sand and shell marl | “ | Patomac Creek, Va. | 84.52 | 0.85 | 0.08 | 1.04 |
| 1147 | “ “ “ “ | “ | Seat Pleasant | 50.59 | 9.10 | 0.16 | 0 64 |
| 879 | Green sand marl | “ | T. B. | 86.46 | 1.25 | 0.19 | 0.59 |
| 880 | “ “ “ | “ | “ | 91.65 | 0.90 | 0.41 | 0.42 |

TABLE VII—*Continued*,

| Laboratory No. | Description and source of sample. | Insoluble matter. | Lime CaO | Phosphoric acid $P_2O_5$ | Potash $K_2O$ |
|---|---|---|---|---|---|
| 1029 | Shell marl “ . Patomac Creek, Va. | 59.09 | 17.30 | trace | 0.33 |
| | CRETACEOUS. | | | | |
| 1146 | From Seat pleasant. | 78.11 | 2.45 | 0.18 | 0.65 |
| | UNCLASSIFIED MARLS AND MISCELLANEOUS. | | | | |
| 1166 | Lime marl, 20 feet below surface, Sent by W. G. Worman, Frederick | 8 80 | 50.10 | 0.08 | 0.28 |
| 799 | Marl from near surface “ George Earle, Millersville | 75.39 | 12.19 | 0.48 | 0.21 |
| 798 | “ “ “ “ “ “ “ “ | 87.90 | 1.62 | trace | 0.38 |
| 800 | “ “ “ “ “ “ “ “ | 92.90 | 1.25 | “ | 0.16 |
| 1148 | Dirt from a well “ W. O. Reeder, Laurel Grove | 76.69 | trace | 0.29 | 1.52 |
| 8 8 | River mud, “ A. T Parsons, Salisbury | 73.05 | “ | 0.19 | 0.39 |
| 1169 | Shell and sand marl, “ J. L. Rowland, St. Mary's coun y. | 82.81 | 7.37 | 0.16 | 0.43 |
| 1413 | Lime and shell marl, “ Alonzo Berry, Williamsport | 0.77 | 54.75 | 0.08 | 0.19 |
| 1451 | Shell and sand marl, “ R. J. Manning, Accokeek | 52.78 | 15.87 | 0.08 | 1.76 |
| 1455 | Clam shell marl, partly decomposed, “ T. B. Dyer, Oxen Hill | 64.28 | 11.25 | 0.04 | 1.81 |
| 1456 | Sand marl, “ “ “ | 89.21 | trace | 0.28 | 0.32 |
| 1457 | Shell marl, “ “ “ | 64.08 | 18.12 | 0.20 | 0.40 |
| 1458 | “ “ “ “ “ | 34.21 | 33.87 | 0.24 | 0.34 |
| 1459 | Sand marl “ “ “ | 77.74 | 0.05 | 0.36 | 0.80 |
| 1460 | *Bone found in marl deposit. “ “ “ | 2.46 | ...... | 30.41 | 0.40 |
| 1541 | Decomposed stone. “ W. S. Whiteford, Whiteford | 89.42 | trace | trace | trace |
| 1726 | Shell marl, M. A. E. S. | | | | |
| 1730 | “ “ “ J. B. Hallowell | 22.83 | 27.25 | trace | trace |
| 1731 | “ “ “ “ “ | 29.30 | 35.25 | trace | trace |
| 1738 | Shell and sand marl “ Randolph Humphreys, Salisbury | 63.58 | 2.15 | trace | trace |
| 1741 | “ F. G. Ankum, Washington, D. C. | 59.75 | 7.25 | trace | trace |
| 2075 | Shell marl, “ Wm. B. Reed, Sr., Centreville | 51.32 | 24.20 | 1.40 | trace |
| 2076 | Green Sand Marl, “ “ “ “ | 70.90 | 1.20 | trace | trace |
| 2117 | Shell marl, “ Edward Lynch. Westminster. | 69.42 | 11.60 | ...... | ...... |
| 2129 | Shell marl, “ J. J. Collins, Bishopville | 68.92 | 13.64 | ...... | ...... |

*The bones had the appearance of vertebra.

## EXPERIMENTS CONDUCTED WITH THE USE OF LIME ON THE MARYLAND EXPERIMENT STATION FARM.

The First experiment made at the Station, after its establishment, was planned and conducted by Albert I. Hayward, then the Station Agriculturist. This test was made during 1889, 1890 and 1891. The land used was a sandy loam lying on the South-Eastern part of the farm and South of the present tobacco houses. This land was naturally well drained and a good kind soil, but it had been badly neglected in previous years so that it did not give very large yields. The weather conditions, during these years, were not favorable for the crop, and the varieties of seed used proved to be unadapted to this soil and climate, yet the results are comparative.

The crop used in the test during 1889 and 1890 was corn; in 1891 wheat was used.

The following table gives the program of the experiments, and the results with the various crops.

TABLE VIII.

*Results with the use of Different forms of Lime on Corn and Wheat.*

(Yields per acre in pounds.)

| Plot No. | Application. | Quantity per A. | 1889—Corn. Fodder ℔s | 1889—Corn. Grain ℔s | 1890—Corn. Fodder ℔s. | 1890—Corn. Grain ℔s | 1891—Wheat Straw ℔s | 1891—Wheat Grain ℔s | Total crop 3 yrs Straw ℔s | Total crop 3 yrs Grain ℔s |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Nothing, | ...... | 2040 | 1360 | 1820 | 2625 | 103 | 18 | 3963 | 4003 |
| 2 | Land Plaster. | 370 | 2242 | 1470 | 2140 | 3094 | 358 | 102 | 4740 | 4666 |
| 3 | Lime, | 2000 | 2352 | 2048 | 2780 | 3056 | 2213 | 642 | 7345 | 5742 |
| 4 | Shell Marl | 8000 | 2016 | 1312 | 2420 | 2874 | 1156 | 354 | 5692 | 4540 |

In the above test it will be noted that lime was applied in three forms: viz.—on plot 2, the Sulphate as furnished by land plaster; on plot 3, the oxide or quick lime; and on plot 4 the carbonate, as furnished by the shell marl.

The results as given in table VIII show that the sulphate of lime and the quick lime produced marked effects the first year of application, but that the corbonate showed no effect until the second year. In the sum total of the three years crops, all of the applications proved to be quite beneficial and the quick lime produced the greatest increase in yields.

The next test that was instituted was started in 1890, and was planned and conducted by Albert I. Hayward. The soil used for this test was a stiff clay with gravel subsoil. The piece of land used was situated north of the Station buildings and east of the Pike. This land was a stiff clay, naturally inclined to be wet, and had been steadily cropped in previous years, having received little, if anything, in the way of manure or fertilizer.

The plots were seeded to wheat in the fall of 1889, and cropped the same year without any fertilizer or other application, so as to determine the inequalities of the land. In the spring of 1891 the plots were planted to corn. The plots were one-tenth of an acre each. The following table gives the results obtained:

TABLE IX.

| | 1890—Wheat | | | 1891—Corn | | | |
|---|---|---|---|---|---|---|---|
| Plot | Application | Grain bu. | Straw lbs | Application. | Quantity per A | Grain lbs | Fodder lbs |
| 1 | Nothing | 13.9 | 1364 | Stone Lime | 2000 | 3570 | 7050 |
| 2 | “ | 13.2 | 1330 | Oyster shell Lime | 2000 | 3320 | 6500 |
| 3 | “ | 12.1 | 1771 | Ground “ “ | 2000 | 3540 | 7180 |
| 4 | “ | 9.1 | 816 | Marl | 4000 | 3200 | 4500 |
| 5 | “ | 11.6 | 1106 | Land Plaster | 233 | 3180 | 4700 |
| 6 | “ | 11.4 | 1255 | Nothing | ..... | 2030 | 4050 |
| 7 | Complete Com. Fert. | 16.8 | 1783 | Complete Commercial fertilizer. | 693 | 3740 | 8200 |

## DISCUSSION OF RESULTS.

In this test the same forms of lime were used as in that reported in table VIII, with the addition of the use of Oyster shells both burned and ground. The results obtained are exhibited in table IX.

These results, while covering but a single year, show, however, that all these various applications had the power of materially increasing the yields. The results obtained with the carbonate of lime as furnished by the ground Oyster shells and the marl, are particularly interesting, and it is unfortunate that the effect of these could not have been studied in connection with a variety of crops and covering a series of years.

Owing to changes in the experiments to be conducted, these plots were abandoned and others were substituted, taking up a little different study with limes.

## TESTING THE EFFECT OF LIME ON THE USUAL MARYLAND ROTATION.

This experiment was commenced in the spring of 1893, and was planned by Director Robert H. Miller and conducted under his direction until the time of his resignation in 1898. The results, up to that time are summarized in Bulletin No. 56.

“The object of the experiment was to note the effect of lime on a series of crops. Commencing with corn followed by wheat and two crops of hay. This rotation to be repeated with another application of lime previous to planting corn.” Two plots of one-quarter acre each were used in the test. One of these plots received an application of 20 bushels of stone lime per acre and the other received none. The other treatments of these two plots were uniform throughout. The details of the yields of the plots, up to the end of 1897, are given in Bulletin No. 56 a summary of which will be found in the following table, together with the results obtained since that time.

Crimson clover was seeded in the corn at the last working on July 24th, 1897. This made a fair stand and growth. It was turned under on May 28th, 1898, and the land harrowed from time to time during the summer, and seeded to Rocky Mountain wheat on September 29th, 1898. There was 400 pounds of fertilizer applied per acre at time of seeding the wheat. This fertilizer was made up of S. C. Rock—1200 lbs.; Tankage—

400 lbs.; Nitrate of Soda—100 lbs.; and Muriate of Potash—300lbs. This would analyze approximately 9.75 per cent. Phosphoric Acid; 2 per cent Nitrogen and 7.50 per cent Potash.

Timothy was seeded in the fall at the rate of six quarts per acre, and six quarts of clover in the spring. The wheat was harvested in June, 1899. The yields will be found in the following table:—

TABLE X.

*Yield per Acre of Limed and Unlimed Plots for Six Years.*

(Size of Plots used, one-fourth acre).

| Crop and Year. | Plot 1, Limed | | Plot 2 Unlimed | | Gain as a result of Liming. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Grain. | | Hay or Fodder | |
| | Grain bu | Hay or Fodder ℔s | Grain bu | Hay or Fodder ℔s | Bushels | Per cent | Pounds | Per cent |
| Corn—1893 | 21 4 | 2200 | 15.8 | 1792 | 5.6 | 34.7 | 480 | 18.1 |
| Wheat—1894 | 31.3 | ...... | 22.8 | ..... | 8.5 | 37.3 | .... | ..... |
| Hay—1895 | ...... | 2662 | ..... | 1391 | .... | ...... | 1271 | 91.3 |
| Hay—1896 | . | 756 | . | 360 | .... | ...... | 396 | 110.3 |
| Corn—1897 | 43 6 | 2015 | 26.0 | 1475 | 17.6 | 66.4 | 540 | 39.8 |
| Wheat—1899 | 31.4 | 1014 | 22.5 | 768 | 8.9 | 39.6 | 246 | 32.0 |

Rating corn at 40 cents per bushel; fodder at 20 cents per Cwt., hay at 50 cents per Cwt, straw at 25 cents per cwt., and wheat at 70 cents per bushel, and allowing 18 cents per bushel as the cost of the lime, the total value of the grain resulting from the liming of the land would be $32.30; which, after deducting the cost of the lime $7.20, would yield a net profit of $25.10, or $4.18 per year. It is of interest to note that increases in the hay alone more than paid for the lime applied. These figures are sufficient evidence to prove that the application of lime to this land was a beneficial and profitable proceedure.

## TESTING THE IMMEDIATE AND LASTING EFFECTS OF DIFFERENT QUANTITIES OF LIME.

This experiment was commenced in the spring of 1896. It was planned by Robert H. Miller, Ex-Director of the Station. The land used in this test is a portion of the sub-division of College Park, and is situated adjoining and East of the Pike and North of College Avenue. This piece of land is a stiff clay, and inclined to be a little wet. It had not been under cultivation for a number of years, and was very poor and unproductive. The only growth on the land, previous to taking it for experiments, was dew-berries with some sedge grass and Golden Rod, but these had accumulated very little vegetable matter, as the custom was to burn it over annually. A more detailed description of the land and of the crops of 1896 and 1897 is given in bulletins Nos. 46 and 56.

When the plots were seeded to wheat they all received an application of fertilizer at the rate of 600 pounds per acre, and were seeded down with timothy and clover. The following table gives the quantities applied to the various plots, and the yields of the crops up to date. The land was plowed in the spring, and, the lime, which was slaked by means of water to a powdery condition, was applied by means of a shovel and immediately harrowed into the land. For the corn crop of 1899 the plots were plowed on April 12th and planted on May 10th. There was no fertilizer used on the corn.

### TABLE XI.

*Quantity and Cost of Lime Applied per Acre, and Yield per Acre of the various Crops.*

| Plot No. | Quantity of lime bu. | Cost of lime $ | Corn 1896 bu | Wheat 1897 bu | Hay 1898 lbs | Corn—1899 | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grain bu | Fodder lbs |
| 1 | 10 | 1.80 | 23.9 | 26.0 | 2502 | 35.2 | 1845 |
| 2 | 20 | 3.60 | 25.6 | 27.7 | 2367 | 28.5 | 2070 |
| 3 | No lime | ...... | 17.4 | 22.5 | 972 | 30.5 | 1845 |
| 4 | 30 | 5.40 | 25.8 | 28.7 | 2205 | 34 8 | 2160 |
| 5 | 40 | 7.20 | 27.1 | 31.9 | 2322 | 36.5 | 2025 |
| 6 | No lime | ...... | 15.3 | 22.7 | 1053 | 23.4 | 1755 |
| 7 | 50 | 9.00 | 28.8 | 31.0 | 2133 | 39.8 | 2115 |
| 8 | 60 | 10.80 | 29.8 | 32.5 | 2286 | 42.4 | 2295 |

### TABLE XII.

*Value of Gains Produced per Acre with Different Quantities of Lime.*

(In dollars and cents.)

| Plot No. | Quantity of lime bu | Value of lime $ | Value of gain of corn at 30cts bu. 1896 | Value of gain of wheat at 90cts bu. 1897 | Value of gain of hay at 50cts cwt. 1898 | Value of gain of Corn 1899. | | Total value of Gains | Relative profits from gains. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Grain at 40cts bu. | Fodder at 20cts cwt. | | |
| 1 | 10 | 1.80 | 2.28 | 3.06 | 7.45 | 3.28 | 0.09 | 16.16 | 14.36 |
| 2 | 20 | 3.60 | 2.79 | 4.59 | 6.78 | 4.60 | 0.54 | 19.30 | 15.70 |
| 3 | No lime | .... | .... | ..... | ..... | .... | | | .... |
| 4 | 30 | 5.40 | 2.85 | 5.49 | 5.97 | 3.12 | 0.72 | 17.97 | 12.57 |
| 5 | 40 | 7.20 | 3.24 | 8.37 | 6.55 | 3.80 | 0.45 | 22.41 | 15.21 |
| 6 | No lime | .... | | ..... | ..... | ...... | | ... | ...... |
| 7 | 50 | 9.00 | 3.75 | 7.56 | 5.60 | 5.12 | 0.63 | 22.66 | 13.66 |
| 8 | 60 | 10.80 | 4.05 | 8.91 | 6.37 | 6.16 | 0.99 | 26.48 | 15.68 |

The above tables present the results so clearly that it is almost useless to say anything further than to call attention to the fact that small applications of lime have proven to be as efficient at the end of four years as the larger applications, and that the relative profits, up to date, are in favor of applying 20 bushels per acre. It is of interest to note that in the hay crop the ten bushels of lime gave the largest net return.

## TESTING THE VALUE OF LIME IN CONNECTION WITH GREEN MANURE.

This Experiment was inaugurated in the spring of 1896, by Ex-Director Robert H. Miller. Two plots were used in the test. They were contiguous to those used in testing the different quantities of lime. The details of the first treatment of these plots were as follows:

The plots were plowed and prepared for seeding on May 12th., when 40 bushels of stone lime was applied to plot 10; plot 9 receiving none. On the 13th., cow peas, at the rate of five pecks to the acre, were drilled in on each plot without any fertilizer. There was quite an apparent difference in the growth of peas on the two plots, both the color and density of the growth, being in favor of the plot receiving the lime. On August 24th the peas in both plots were plowed down. October 2nd they were seeded to wheat, one and one-half bushels to the acre, and six quarts of timothy seed sown. Four-hundred pounds of fertilizer of the same composition as that used on varieties of wheat, was applied. Clover seed was sown on both plots the following spring. The wheat was harvested in 1897. In 1898 hay was taken from these plots, and in the fall they were plowed, and planted to corn in May, 1899. The yields of these crops are given in the following table. The plots were numbered 9 and 10, as they were in the same series as those tabulated on page 126.

The average yield of the no limed plots are repeated here for comparison.

TABLE XIII.

*Yields and Value of Gains Resulting from the Use of Cow peas and Lime as Soil Improvers and Renovators.*

| | No Lime. | | Cow Peas and no lime. | | Cow Peas and Lime | | | |
|---|---|---|---|---|---|---|---|---|
| Crop & year | Grain bu. | Hay or Fodder lbs. | Grain bu. | Hay or Fodder lbs. | Grain bu | Hay or Fodder lbs. | Value of gain from Cow Peas. $ | Value of gain from Lime and Cow Peas $ |
| Wheat, 1897 | 22 6 | | 32.4 | .... | 34.0 | | 8.82 | 10 26 |
| Hay, 1898 | | 1012 | ..... | 1062 | ... | 1638 | 0.25 | 3.13 |
| Corn, 1899 | 27 0 | 1800 | 22.8 | 1215 | 27.0 | 1845 | (-2.85 | 0.09 |
| | | | Total | | | | 6.22 | 13.48 |
| | | | Cost of Peas and Lime | | | | 1.25 | 8.45 |
| | | | Net Gains | | | | 4.97 | 5.03 |

The same prices were given the respective crops in calculating the value of the gains as were used in table XII page 126

The results obtained in this experiment are in favor of using both cow peas and lime, combined as soil renovators. These results would seem to indicate that the combination had the greater lasting qualities, and also that it would probably be necessary to repeat the use of the peas more frequently.

## TESTING THE USE OF DIFFERENT KINDS OF LIME AND SOME OTHER AMENDMENTS.

With a view of studying the effects of different kinds of lime, and different modes of applying the same lime; also of endeavoring to test if the land was responding to lime as a plant food or only needing chemical and physical changes, the following series of experiments were outlined and entered upon in the spring of 1895. The land used in this test is of about the same character as that used in the test described on page 123, and is separated from it by a road 15 or 20 feet wide.

This piece of land was planted in cherry trees in 1889 and kept cultivated, but not cropped in the mean-time. Many of the cherry trees had died out, and the remaining ones had made but little growth, so they were pulled out. For this test the land would permit of plots only ten feet wide and sixty seven feet long with a two foot space between each plot. This gave the plots practically one-sixty-fifth of an acre each. The plots were plowed May 24th 1895, and lime was applied on May 25th. This is the only application of lime which has been made up to this date (May 1900).

The following table gives the application which was made to each plot. The quantities applied in the case of lime, were such as to give each plot the same quantity of Calcium Oxide, which was determined by analysis. Plots are numbered from tobacco barn toward the south.

TABLE XIV.

*Lime Experiments.*

(Size of plots, 10x67 feet, with 2 feet space.)

| Plot No. | Description of Application. | Quantity per acre, lbs |
|---|---|---|
| 1 | Stone lime (Calcium Oxide, $CaO$) Fresh slaked and applied as a top dressing, not harrowed into the soil. ...... ...... | 1400 |
| 2 | Stone Lime (Calcium Oxide $CaO$). Freshly slaked and harrowed into the soil immediately........................................ | 1400 |
| 3 | Oyster Shell Lime (Calcium Oxide $CaO$). Freshly slaked and thoroughly worked into the soil immediately........... | 1400 |
| 4 | Oyster Shell Lime (Calcium Oxide $CaO$). Worked into the soil before slaking...................................... ............. ...... | 1400 |
| 5 | Magnesium Oxide ($MgO$), worked into the soil with harrow. | 1400 |
| 6 | Barium Oxide ($BaO$) worked into the soil with harrow......... | 1400 |
| 7 | Nothing................... ............. ........................................... | |
| 8 | Shell marl (Calcium Carbonate $CaCo$), Worked into the soil with harrow.................................................................. | 13000 |
| 9 | Finely ground oyster shells (Calcium Carbonate, $CaCO$)...... | 2600 |
| 10 | Land Plaster, Gypsum (Calcium Sulphate, $CaSO$) .............. | 4125 |
| 11 | Gas Lime........ ...... .................................................. | 2925 |
| 12 | South Carolina Rock, finely ground (Calcium Phosphate $Ca P O$)........ .... ........................................................ ...... | 2925 |
| 13 | Soft coal ashes ........................................................... | 13000 |
| 14 | Complete Com. Fertilizer. { Double Superphosphate...200<br>Tankage ..... ......... .........100<br>Sulphate of potash......... 80 } | 380 |

The plots were planted in corn on May 25, 1895, putting three rows to each plot. At the last working of the corn on July 8th the plots were seeded to crimson clover. This clover made a good stand and growth and was turned under on May 14 1896, and again planted to corn on May 26th. The clover was cut September 17th, and the land plowed on October 1st, and thoroughly prepared and seeded to wheat on October 2nd, 1896. There was commercial fertilizer applied at the time of seeding the wheat, at the rate of 600 pounds per acre. This fertilizer was made up as follows:—

| | |
|---|---|
| Dissolved South Carolina Rock | 1000 lbs. |
| Tankage 10 per cent | 500 " |
| Nitrate of Soda | 300 " |
| Muriate of Potash | 200 " |
| | 2000 |

This fertilizer had approximately the following composition: Phosphoric Acid, 9 per cent; Potash, 5 per cent; Nitrogen, 3½ per cent. The wheat was harvested in June 1897. The plots were seeded with timothy and clover in the wheat, which were allowed to go for hay. Hay was cut June 23rd and hauled in June 27th 1898. On April 14th, 1899, these plots were plowed and thoroughly prepared and planted to corn on May 15th. There was 500 pounds per acre of commercial fertilizer applied broadcast before planting the corn. The fertilizer contained 9 per cent Phosphoric Acid, 7½ per cent Potash, and 2½ per cent Nitrogen.

The yields of the various crops are given in the following table:—

TABLE XV.

| Plot | 1895—Corn. | | 1896—Corn. | | 1897—Wheat | | 1898 | 1899—Corn. | | Total Yield 5 yrs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain lbs. | Fodder lbs. | Grain lbs. | Fodder lbs. | Grain lbs. | Straw lbs. | Hay lbs. | Grain lbs. | Fodder lbs. | Grain lbs. | Fodder & Straw lbs. |
| 1 | 2989 | 2308 | 2604 | 1950 | 940 | 1202 | 1560 | 1226 | 4875 | 7759 | 11895 |
| 2 | 3024 | 2113 | 2408 | 1900 | 1007 | 1397 | 2535 | 751 | 4550 | 7190 | 12545 |
| 3 | 2828 | 2145 | 2695 | 2275 | 875 | 1300 | 2405 | 975 | 3900 | 7373 | 12025 |
| 4 | 2936 | 2080 | 2541 | 2145 | 1037 | 1527 | 2665 | 807 | 5200 | 7321 | 13617 |
| 5 | 2716 | 2210 | 2408 | 2047 | 1202 | 1786 | 2210 | 1644 | 3250 | 7970 | 11504 |
| 6 | 2576 | 2080 | 2471 | 1852 | 1007 | 1527 | 1820 | 891 | 4875 | 6945 | 12154 |
| 7 | 2490 | 1950 | 1946 | 1885 | 875 | 1462 | 1365 | 529 | 3900 | 5840 | 10562 |
| 8 | 2940 | 2011 | 2989 | 2112 | 1335 | 1917 | 2925 | 1361 | 4550 | 6825 | 13515 |
| 9 | 3416 | 2044 | 3325 | 2535 | 1335 | 1690 | 2600 | 1560 | 5135 | 9636 | 14004 |
| 10 | 2863 | 2470 | 1855 | 2145 | 909 | 1527 | 1235 | 1058 | 3575 | 6685 | 11958 |
| 11 | 2835 | 2178 | 1946 | 1852 | 1040 | 1690 | 1495 | 1170 | 4550 | 6991 | 11765 |
| 12 | 2695 | 2113 | 2416 | 2242 | 1072 | 1527 | 2145 | 628 | 4225 | 6811 | 12252 |
| 13 | 2471 | 1950 | 1687 | 1722 | 802 | 1105 | 1495 | 752 | 3775 | 5712 | 10047 |
| 14 | 2387 | 2011 | 1428 | 1527 | 585 | 1105 | 845 | 1530 | 3900 | 5930 | 9388 |

The results obtained with these plots are, in many ways, very unsatisfactory, as the yields in all cases are not such as would be considered profitable. This, in a measure, is due to not being able to cultivate and prepare such small areas as thoroughly as should be done, and also to the run-down condition of the land and the small amount of organic matter which it contained; but nevertheless the work has been carefully performed and should be comparative. The total yields obtained with the five crops give some peculiar and unexpected results, which cannot be explained by the ordinary and commonly accepted notions as to the action and effects of lime. Some recent investigations in connection with the experiments have shown the land used in these experiments to possess some exceptional and unusal characteristics for this formation, and further study may explain the causes for the results obtained, but these cannot be completed in season for this bulletin so the results will be reported at this time only as a matter of record.

1. It will be noticed that the best yields were obtained with the lime in the form of a carbonate. The finely ground Oyster shells, plot 9, standing first, and the shell marl, plot 8, standing second. This was further substantiated when the stone lime was applied as a top-dressing (Plot 1), and given an opportunity to form carbonate of lime by absorption of carbonic acid from the atmosphere.

2. It will be noticed that pure Magnesium lime, which is commonly claimed to be poisonous to the soil and crop, gave the highest yield.

3. It will be noticed that Barium Oxide, which is not a plant food, produced very nearly as much increase in the yields as the Calcium Oxide, and more increase than the sulphate or phosphate of lime. This would seem to indicate that there was some effect produced on the soil rather than that the plants needed lime as a plant food.

4. It will be noticed that the lime applied so as to slake in the soil (plot 4) produced a slightly better total yield than when first slaked and harrowed in. (plot 3).

5. A comparison of the results of plots 2 and 3, show stone lime and shell lime to be of about the same value on the soil.

6. Lime with fertilizer was more profitable than depending upon fertilizer alone.

7. All the applications of lime increased the yields.

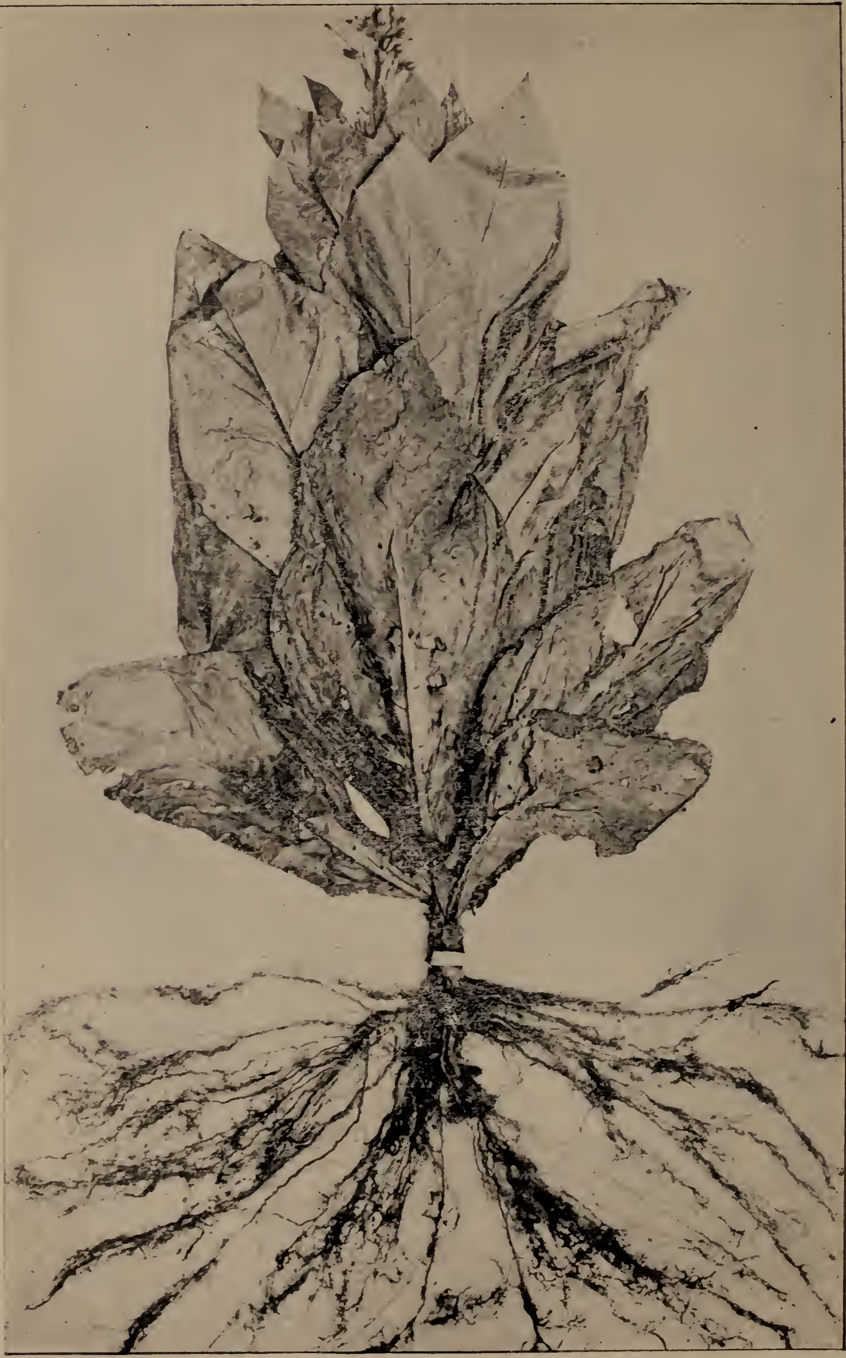

FIG. 31—Root System of Mature Tobacco Plant.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 67. JUNE 1900.

# The Culture and Handling of Tobacco in Maryland.

BY H. J. PATTERSON, DIRECTOR AND CHEMIST.

Tobacco was grown in Maryland by the Indians long before the time of the first white settlers. The early colonists were attracted by it, and soon acquired the habit of its use and spread the same to the mother country. This gave the crop considerable importance for Maryland Colonists, and for nearly two centuries it was closely identified with their social, religious, economic and political development. The crop of 1732 was reputed to be 30,000 hogsheads. at which time it was made a legal-tender at the rate of one penny per pound for all debts, including custom dues and the salaries of State Officers and of Ministers of the Gospel. As late as 1777 the tax rate of Baltimore City and County was fixed at 172 pounds of tobacco per poll.

In 1825, Maryland produced about 15,000 hogsheads of tobacco; in 1846, 41,000 hogsheads, and in 1860, 51,000 hogsheads, which was the largest yield ever produced in the State. During the Civil War the yields decreased until in 1865 it was only 25,000 hogsheads. In 1878 the yield again increased to 46,000 hogsheads, while in 1890 the lowest production of the State ever recorded was 14,000 hogsheads. The yields during the past ten years have fluctuated considerably with the season, as is shown by the figures in table I, but the normal crop might be considered to be about 30,000 hogsheads. This amount could, no doubt, be considerably increased and still meet with ready sale at remunerative prices if the quality were advanced at the same time.

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NOTE :—This Bulletin has not been sent to persons on the general mailing list, but only to those interested in tobacco culture. There are about 1500 names of Maryland farmers who grow tobacco, on our special list, to whom copies of this Bulletin have been sent. All others interested may have a copy of this Bulletin and have their names entered on the special Tobacco Mailing List by requesting the same.

## TABLE I.

*Amount of Tobacco marketed and the Sum paid for Reclamations in Maryland During the Past 10 Years.*

| Year. | Hogsheads. | Reclamation Paid. |
|---|---|---|
| 1890 | 14032 | $ 329.86 |
| 1891 | 27336 | 855.27 |
| 1892 | 22437 | 550.22 |
| 1893 | 25495 | 609.63 |
| 1894 | 38163 | 541.61 |
| 1895 | 28085 | 722.73 |
| 1896 | 29629 | 1202.43 |
| 1897 | 34875 | 2101.75 |
| 1898 | 36292 | 1203.99 |
| 1899 | 31484 | 717.00 |

## USES OF MARYLAND TOBACCO.

The tobacco grown in Maryland is used chiefly for smoking. It is consumed principally in Europe, (France, Germany and Holland.) France and Germany are the heaviest users of Maryland tobacco, and the price is largely dependent upon the French contract.

Each of these markets demands a particular grade of tobacco, and will not take any other grade or quality, even though of a higher value, at corresponding prices.

While it is impossible, owing to several variations, to get specific types as to color and size of leaf used by the different trades in tobacco, yet every farmer should acquaint himself with the general facts as to quality, texture, size of leaf, &c, demanded by the various markets, and do all in his power to have his tobacco graded and packed accordingly.

## METHODS OF SELLING TOBACCO.

Almost the entire yield of Maryland tobacco is sold in Baltimore, where five large ware-houses have been established by the State for the inspection of these goods by State Officers. As soon as a hogshead of tobacco is entered in the ware-house, a sworn and bonded inspector draws six samples of hands from the same. These are taken from different places and at equal distances apart, beginning near the bottom of the hogshead. These six samples or hands are tied together, sealed and labeled with the name of the owner, the number of the hogshead, its net and gross weight and the name of the inspector. The agents of foreign countries buy exclusively by these samples. When the goods are shipped the samples are also forwarded, so that the goods, on reaching their destination, can be compared with the samples by which they were bought. If there should be more than ten per cent. of the tobacco in a hogshead poorer than the sample, the State, through its inspectors, becomes liable for such difference.

There is no charge for storage of tobacco in the State Ware House as long as it belongs to the grower or is in the hands of his agent, but as soon as it is sold there is an outage charge of two dollars per hogshead which is paid by the purchasers. This is paid to the State, and really amounts to inspection charges. The purchaser may leave the tobacco in the State Ware House for six months free of charge, after that time there is a storage charge of ten cents per month per hogshead. The commission charged for selling tobacco is $1.50 per hogshead, which is paid by the grower.

## SIZE OF HOGSHEADS.

There had been considerable contention between the growers and handlers of tobacco, as to the weight of tobacco to be put into a hogshead. On this, as well as on the point of even and uniform grading and packing, there should exist no difference of opinion between purchaser and grower, for the real facts show that their interests on these points are identical, and what benefits the one also benefits the other. The Commission man's interest in the-matter is to have the tobacco in such shape as to enable quick sales, and his commission is the same in either case. The reason for not wanting more than a certain quantity in a hogshead is, that the extreme pressure to which it is subjected in the heavy weights, causes the tobacco to come out of the hogshead bruised and lifeless, so that there is great loss in manufacturing. The trade seldom take heavy weights at all, but in a few cases where heavy weights are persisted in, the price is cut down so as to throw the loss of the waste tobacco on the grower. The reason for not wanting less than a certain weight in a hogshead, is, that the freight rates on shipments to Europe are based upon the space occupied, and not upon the weight; hence light weights run up the cost per pound for freight, and the buyer must cut down the price paid proportionately to meet this expense. The trade custom now, in case of light weights, is to mark the actual weight on the margin of the label on the sample, so that the buyer may make his bid accordingly.

The present season is bringing an unusual number of light hogsheads to the market. This is probably due in most instances to the character of the tobacco being produced last season on soils lacking organic matter; as many soils which have been long under cultivation are, in consequence, quite deficient in this respect.

The size of a hogshead varies considerably, but it is generally 52 inches high and 42 inches in diameter, and costs from one to two dollars according to the price of lumber. The limits between which the weight of tobacco placed in a hogshead should run are, from 600 to 850 pounds. The growers should aim to give these weights and please their customers. It pays well to put all products in a shape to please and attract the buyer. Meet the purchaser's desires first, your own second.

## GRADING AND PACKING TOBACCO.

There is no part of the work of the Maryland grower of tobacco, so poorly, improperly, and sometimes viciously performed, as the grading and packing. Every man that goes into a barn to strip tobacco should be made to understand that each leaf has a particular value, depending upon its size, color and texture, and that he should grade and make up every hand of tobacco accordingly. The work of separating the different grades into hands that will have uniformity as to size, color and texture, should be as faithfully and attentively performed as is the work of the U. S. Treasury Clerk in handling green-backs of different denominations.

After the grading into uniform hands has been properly executed, the tobacco, when sent to market, should be just as conscientiously packed in the hogshead, so that it will contain but one grade of tobacco.

In case a grower has not enough tobacco of one grade to fill a hogshead, the best way is to pack the different grades in separate layers, and not mix it promiscuously. The hogshead containing a number of grades can then be sold to advantage to the re-packer and so give the grower better returns than by placing it on the general market in a mixed condition.

## RESULTS OF BAD GRADING AND FALSE PACKING.

When tobacco comes upon the market with different grades in the same hand, and different kinds of hands, as to size, color or texture, in the same hogshead, it has difficulty in finding a purchaser at any price, and when it is sold the price is such as will permit of throwing out of a grade that does not meet the wants of that particular market for which it was purchased, even though that grade might be considerably better than the bulk. For instance it is not uncommon to find two grades of tobacco mixed in the same hogshead, which if separated, would sell readily for from seven to twelve cents per pound, whereas, in the mixed condition, it is hard to find a buyer for the hogshead at four or five cents per pound.

This loss falls directly upon the grower, and all must concede that such carelessness is being paid for dearly.

There is another kind of grading and packing that is not done through either ignorance or carelessness, and that is the so-called "False packed" hogshead, which is deliberately done with intent to deceive. This is a malicious practice, studied and made a profession of, by many, and indulged in to a considerable extent both by growers and local dealers throughout all parts of the State.

It is this false packing that has done more than any other one factor to demoralize the market for Maryland tobacco. If all the growers of the State had put forth as much effort to study and meet the demands of the tabacco market as some few have put in the study of the art of false packing, the trade for Maryland tobacco would never be dull and the produce never go begging.

As a result of bad grading and false packing there exists in Baltimore to-day a class of dealers who are making good livings and in some instances fortunes, by purchasing mixed hogsheads of tobacco and grading, classifying, repacking and placing them on the market in a condition to meet the demand of a particular market. The profit which this class of dealers makes, represents a portion of the loss which comes to the grower through carelessness in grading and packing.

Every grower should remember that his name goes with every hogshead of tobacco up to the man who manufactures the same into the finished product for the retail trade, and if the tobacco in the hogshead fails in any respect, his name goes back to the buyers to be placed on the blacklist which insures him low prices in the future. On the other hand the grower's tobacco that reaches the manufacturer in good shape, evenly and uniformly graded and honestly packed, brings his name back to the buyer to be placed on a list which is almost a guarantee for quick sales at good prices.

The grower, after considering all these facts, ought to make a careful study of the demands of the markets for tobacco, and put forth every effort to meet the demand. It is just as important for every grower of tobacco to aim to please his customers by giving what is wanted in the shape it is wanted, as it is for the merchant. It is only such a course that will establish a reputation which will bring profit to the industry.

Another evil of false packing is the expense incurred for reclamations. The amount paid in this way during the last ten years is exhibited in Table I, page 132. While this is paid by the State, yet in the end it comes off the growers of tobacco.

One cause of so much being paid for reclamations is the result of poor inspections as performed by new and inexperienced people to whom this work is entrusted. The figures in Table I, show this fact very emphatically, and would seem to warrant the inauguration of some method whereby those entrusted to perform this work would be skilled and experienced persons, and in order to be such there should of necessity be more permanency in the tenure of office of those employed in the State Ware House than the present conditions afford.

## TOPPING TOBACCO.

Some of the lack of uniformity in tobacco is no doubt due to the methods pursued in topping, and to the lack of care and uniformity in performing this part of the work. If the tobacco is allowed to grow too high and have too many leaves it gives a considerable number of what are termed "crop" leaves, which because of the number, will ripen very unevenly. When these are stripped they are ordinarily put all together in the same hand, with the result that bundles are very mixed in appearance and lack that uniformity of color, texture and size that is so desirable.

Topping is one of the most important operations to be performed in tobacco culture, and it should not be done by careless and inexperienced labor; but by those who have considerable judgment.

Topping should be done so as to have fewer leaves per stalk than is very commonly the case. This will throw the growth to those leaves left on the stalk, and what has been lost in numbers will be made up in the weight of the remaining leaves. Not only will the fewer number of leaves weigh more, but they will ripen up more evenly and give tobacco of uniform quality and appearance when cured and stripped which will sell easier and bring a higher price per pound.

There can be given no hard and fast rules for topping tobacco, as the number of leaves that can be properly matured will vary with the kind of soil and variety of tobacco grown. Again, with the same soil and variety, there will be seasonal variations which will have to be observed, and this can be accomplished only by the exercise of good judgment on the part of the person doing the topping.

There is one point that should be almost universally observed, however, and that is to have all the tobacco of the same crop topped uniformly, so that it will ripen evenly and give uniform grades when cured and stripped.

Topping is the pinching out of seed bud which forms as the terminal bud of the stalk. This should be done as soon as the desired number of leaves per stalk are secured and should not be deferred until the plants are in bloom. In pinching out the bud, care should be exercised not to injure the tender top leaves. A very slight injury will develop into serious blemishes when the leaf has reached its fullest expansion.

The arrangement of the leaves on the stalk makes it possible to do the topping without counting but by simply observing the relative position of the lower and upper leaf.

## VARIETIES OF TOBACCO FOR MARYLAND.

In Maryland there are four distinct types of tobacco which are well recognized; viz.: 1, Broad leaf; 2, Broad leaf, thick set; 3, Narrow leaf; 4, Narrow leaf, thick set. There are a considerable number of variations in these types, which might be termed variations due to the character of the land upon which they have been grown, and the methods and standards of selection adopted by the grower.

These types of tobacco are peculiar to this state, and seem to be better adapted to the soil, methods of curing, handling and to the markets which are to be supplied, than any of the imported or socalled improved varieties that have ever been tested. Tobacco experts have in past years, frequently made the statement that all that was necessary to improve Maryland's product was to introduce the proper seed. The proposition has been tested extensively during the past ten years, and in no instance did the new seeds give better results than the old standard sorts, and in most cases the results were disappointing in the extreme, as the quantity and quality were both below the normal.

## METHODS OF IMPROVING VARIETIES.

Investigations have shown that some growers of tobacco have improved both the yield and quality of the particular type of tobacco which they are growing by special care in selecting seed. This is a practice that should be more generally indulged in and given special attention by all growers. There is considerable variation in the character of soil used for tobacco, and the only way to get a variety of tobacco that is particularly adapted to a given soil and also other conditions which surround it at the curing season, is by selection. This is not a hard thing to do, and is much more profitable than to expect to get what is desired by the hit or miss method of getting seed from a neighboring farm or from some other locality.

The first thing to decide upon is the type which is best suited, naturally, to your soil and conditions; then by careful observations pick out the plants that are nearest perfection of that type, and save seed from these plants. Save only the seed that is produced on the main or central seed stalk. Cut out all the suckers or lateral seed producing stems, and do not allow them to mature, but throw the strength into the other seed. Then after this seed is ripe, sift out the small, immature and shriveled seed, and throw them away. Planting nothing but the best developed seed it is possible to grow. Following this course rigidly for a few years will result in an almost new variety which will be particularly adapted to a particular farm, and result in improving the yield and quality of the product.

Improving varieties by selection is the only rational method to be pursued by the average farmer, and is precisely the method followed by breeders of stock and by some of the best grain growers, and is especially noted with corn.

## CIGAR VARIETIES OF TOBACCO.

There has been a considerable number of experiments performed at this Station with reference to growing tobacco for cigars. These tests have shown that on good land, which is rich in organic matter, by the use of imported Cuban seed it was possible to produce a larger tobacco of fair quality. The most promising tobaccos grown were those intended for filler, and were of the varieties commonly known as Havana, Partidas and Remedios. These as well as Sumatra, produce some fair binders and wrappers, but the proportion which could be used for this purpose was very small. The filler grown so far, when made up, proved to be above the average of the five-cent cigars found on the market. While so much is encouraging as to quality, yet the yield was so much smaller than that given by the Maryland varieties, which, together with the additional care and cost of handling, made the total expenses incurred, more than would be compensated for by the extra price received per pound for the tobacco. Again it would require the market to be specially educated to take any quantity of Maryland cigar leaf, and this would add to the uncertainty of the profits in the product.

## THE PLANT BED.

In order to have plants early and get the crop set in season for it to mature in August, so as to be able to avail of good weather for curing, and to avoid the harmful effects of the foggy, wet and muggy weather that is common later, it is necessary to make provision for insuring plenty of plants earlier than was the custom a few years ago.

Plants may be had in good season and in abundance by covering the beds with Plant or Hot-bed cloth. This cloth costs about two cents a yard, and not only protects the plants from sudden and severe changes of the weather, making them develop more rapidly, but also shuts out and gives almost complete protection from the "Flea" beetle, which so commonly kills all the plants. The plants should be uncovered after they have gotten a good start and the danger of the beetle is past, and left uncovered entirely for three or four days before transplanting to the field in order to make them harder.

## THE USE OF GREEN MANURE FOR SUPPLYING HUMUS AND IMPROVING THE YIELD AND QUALITY OF TOBACCO,

The quality and yield of Maryland tobacco have decreased considerably year by year in a large measure owing to a deficiency of organic matter in tobacco soils. Most tobacco soils, as well as all soils of the State that have been extensively planted in cultivated crops, have had the organic matter burnt and worked out of them, with the result that the crops now suffer considerably from the extremes of either wet or dry seasons; and also cannot make proper use of the plant foods that are in the soil or are supplied by the use of commercial fertilizers. The cultivation of soils in this condition gives disappointing returns. both as to the quality and quantity of the crop.

The lands on the Experiment Station farm were very deficient in organic matter for tobacco, and, in order to test the means for supplying this, a piece of land was set aside for tobacco in 1894 and has been cropped in tobacco ever since. The course of procedure was to plant the land in tobacco in 1894 in its natural condition but giving a liberal supply of commercial fertilizer. The crop gave a light yield of poor quality which fired badly, giving a large proportion of ground leaves. The crops have all been set early so that the tobacco has been harvested the last of August or the first week in September. As soon as the tobacco was off the land it was worked up with a spring-toothed harrow and seeded to crimson clover covering the seed with a smoothing harrow. The clover came up well every year, but 1899, stood the winters and gave a large amount of green matter to turn under for the succeeding crop. This green manure was supplemented with commercial fertilizer in 1895, 1896, 1897, but in 1898 and 1899 no fertilizer was applied.

As a result of this treatment the crops increased in quantity and quality, and in 1897 the crop was over three times as heavy as in the year 1894. Another noticeable effect of the land being filled with humus was in preventing the crop from firing and losing ground leaves. This was so pronounced with the crop of 1898 as to cause all who saw it to mention the fact. It will be remembered that the crop of the State in 1898 had a larger proportion of ground leaves than ever before known in the trade. In some cases more than one-half of the crop marketed, was ground leaves. The result with the station crop must have been due to the organic matter in tho soil; as the meteorological report showed the lowest rainfall of the State during the critical month to be at the Experiment Station.

By getting the crop of tobacco planted early, from May 10th to June 1st, it will mature so as to leave the land clear for seeding down to crimson clover by the first of September, and certainly not later than the tenth. This will give time for the clover to become sufficiently established to stand the winter, and will give a large amount of matter to turn down the following April or first of May for the succeeding crop of tobacco. This method has the advantage of not only filling the land with organic matter, but also being able to crop the land which is especially adapted to tobacco growing for a number of years in succession.

Should it happen that crimson clover would not do on some land, or that this crop should not suit the convenience of the grower, cow peas could be used for acquiring organic matter.

The deficiency of organic matter in the soil is the cause of tobacco being chaffy and light in weight, and the only way to prevent the light weight hogsheads, which are now so numerous, is to fill the land with humus.

## FERTILIZERS FOR TOBACCO.

The first essential in producing a good crop of Maryland tobacco is to fill the land with organic matter. This is necessary not only for its physical effect upon the soil, but also in order that the applications of commercial fertilizers may be properly availed of by the crop. There is no crop that is grown in Maryland that is so susceptible to improvement or to injury by fertilizer as tobacco. Tobacco growers have paid entirely too little attention to the effect of fertilizers on the quality of their product, and it is not uncommon to find that even the manufacturers of fertilizer have but little knowledge upon these points. The deterioration in the quality of tobacco in some sections, and the prevailing low price, is, no doubt in a large measure due to the prevailing ignorance of both the manufacturer and the user as to the effect of different fertilizing elements upon the quality of the product. Again we find some farmers and fertilizer manufacturers often recognize the fact that certain elements produce harmful results upon tobacco, and mix fertilizers accordingly, but there they entirely ignore these facts in preparing fertilizers for other crops which are to be grown on land which has tobacco included in its rotation, presuming, probably, that the harmful results are only temporary and will be dissipated by the other crops grown, but the truth is that the other crops increase rather that lessen the harmful effects of those elements.

The quality of tobacco is something that is not well defined, either from a chemical or physical standpoint. The quality is dependent upon innumeral conditions so that it most frequently becomes impossible to say what special ingredient or class of substances improves or reduces the quality of tobacco. The Agricultural Chemist, in his experiments, is unable to judge for himself, whether he has accomplished an improvement or not, as he can in the case of a starch or sugar producing plant, but he must depend upon the opinion of the expert dealer or user. Even in this, experience has shown that it is difficult to get correct estimates, and, particularly in the case of the users of tobacco, much depends upon the kind of tobacco they have been accustomed to using. There are, however, a few well defined facts which have been clearly determined and upon which methods of fertilization can be based. The bulk of the Maryland tobacco crop is used for smoking, having a special reputation in all the markets of the world because of its good burning qualities. The essential property of a good smoking tobacco, in addition to flavor and aroma, rests in possessing the proper "combustibility", i. e., that it shall continue to burn or remain incandescent for some time after being ignited and shall produce a light gray or white ash, and in cigars that the ash shall be held together.

The combustibility is materially affected by curing, but investigations have shown that combustibility is not wholly dependent upon the extent of fermentation, but that the steadiness and persistency with which a tobacco burns is largely influenced by the composition of the ash which is left after ignition, that is upon the proportion and combination of the mineral constituents of the plant. Bearing these facts in mind it will be evident that an important part to observe in fertilizing tobacco is to have a due regard for quality, particularly the point of combustibility. In applying fertilizers or manures of course it is always desirable to produce an increase in the yield, and with most crops this is the primary and almost the sole object of fertilization, as it is from the increased yield that the profits are derived. With tobacco a very different condition prevails, as it is often easy to produce an increase in the yield, but the product will be of an inferior quality, and consequently the total value of the crop much less than it would have been without fertilization. Again fertilizers will often show little, if any, increase in quantity, but cause a decided improvement in quality, and thus returns by advancing the price received per pound. Experiments that have been conducted at this Station with fertilizers on tobacco have emphasized the above facts. These tests included the use of yard manure, lime, magnesia, phosphoric acid, and different forms of potash, and various combinations of these.

The application of yard manure and proper complete commercial fertilizer produced tobacco of about the same quality and combustibility. Lime and magnesia compounds, in small quantities, seemed to produce but little effect, but in large quantities caused a growth that ripened unevenly and was hard to cure, yet with slightly improved combustibility, but, on the whole, the application of lime immediately before planting tobacco cannot be recommended.

Phosphoric Acid seemed to have but little direct bearing upon the combustibility, but generally produced a marked increase in the yield. The results obtained showed the Potash salts to be the most potent factors in effecting the composition and quality of the tobacco produced. The muriate of potash, Kainit, low-grade sulphate of potash or double-manure-salt, and all potash fertilizer which contains considerable chlorine, caused the tobacco to be of poor quality, and combustibility burning with a flash and having a black charry ash. Hence this class of potash fertilizers, and any substance like common salt which contains much chlorine, should never be applied to tobacco or to land that is to be cultivated in tobacco.

The potash fertilizers, which proved to be beneficial to tobacco, improving both the quality and yield, were those furnishing the potash in the form of the sulphate or the carbonate.

The following materials are well adapted for use in making fertilizers for tobacco:

Dissolved South Carolina Rock, Dissolved Bone, Dried Fish, Bone-tankage, Cotton-seed Meal, Nitrate of Soda, Sulphate of Ammonia, High-grade Sulphate of potash, Carbonate of potash and magnesia, and cotton-seed-hull ashes. As a rule in mixing fertilizers there is not as much Nitrogen and Potash used as would be beneficial and profitable. By the use of crimson clover and cow-peas for adding humus to the soils the amount of nitrogen or ammonia furnished by commercial fertilizer could be either kept low or reduced. Farmers should generally aim to mix their own fertilizers, as by this means they are sure of what goes into the fertilizer, and, as a rule, they get the plant food cheaper than by purchasing it in ready-mixed goods. The mixing of fertilizer can be easily and cheaply done on the barn floor, by the aid of a hoe, shovel and sand screen.

The following figures give the approximate per centage which each one hundred pounds of the various ingredients will represent when they are added to a mixture and the whole made up to a ton or 2,000 pounds:

Each 100 pounds of Dis. S. C. Rock represents 7-10 per cent of phosphoric acid in a ton mixture.

Each 100 pounds of standard dried fish or tankage will represent ½ per cent. of ammonia and 4-10 per cent. of total phosphoric acid in a ton mixture.

Each 100 pounds of Nitrate of soda will represent about one (1) per cent. of ammonia when made up in a ton mixture.

Each 100 pounds of High grade Sulphate of potash will represent about 2½ per cent. of potash when made up into a ton mixture.

For illustration, a fertilizer which has been used with good results on the Station farm for tobacco was made up as follows:—

| | |
|---|---|
| Dissolved South Carolina Rock, | 1300 |
| Tankage (10 per cent), | 400 |
| Nitrate of Soda, | 100 |
| High-grade Sulphate of Potash, | 200 |
| Total, | 2000 |

This contained approximately—

| | |
|---|---|
| Phosphoric Acid ($P_2O_5$), | 9 to 10 per cent |
| Potash, ($K_2O$), | 5 " |
| Ammonia, | 3 " |

Sulphate of Ammonia and Nitrate of Soda are particularly valuable for use on the plant beds for growing strong and early plants. For this purpose they are applied at the rate of about 100 pounds per acre, sown broad-cast over the land in which case they are mixed with rock, plaster, or dry earth in order to facilitate application. They are also sometimes applied in solution at the time of watering the plants, in which case they are added to the water at the rate of one ounce of material for every four or five gallons of water.

## THE RELATION OF ORIGINAL AND NATURAL VEGETATION TO THE ADAPTABILITY OF SOILS FOR TOBACCO CULTURE AND THE MEANS BY WHICH CULTIVATED PLANTS CAUSE TOBACCO SOILS TO DETERIORATE.

It is a well known fact used as a guide in actual practice that the original and natural growths of a soil indicate the adaptability of the soil for tobacco culture. It is also a well recognized fact that certain crops will materially change the adaptability of a soil to the production of good tobacco, that it is often impossible to produce good tobacco after the soil has been cropped with certain plants, and that the soil is always deteriorated by being cultivated for those crops. The question now comes,—what is the relation between those plants and the tobacco plant, and why should the marked deterioration take place?

We have seen in the discussion of the relation of the elements contained in the ash of the tobacco plant, *that the food given to the plant has a marked influence upon the quality of the product. We have learned that chlorin, when present in the soil in large quantities, is taken up by the tobacco plant to such a degree as to injure the burning quality considerably, probably by modifying the alkalinity of the ash.

Now let us see if the feeding habits of the plants which grow naturally on our lands and of those which we commonly cultivate, do not in some way account for the preference of certain soils for tobacco and also account for the poor quality of tobacco raised after the land has been cropped in some of our other crops. In the study of the ash constituents of the tobacco plant, chlorin and potash seem to have the most marked effect upon quality; consequently, we should naturally expect to find that those elements of the soil and their relation to other crops should throw some light upon the question under consideration.

In order to study this phase of the question, the chlorin and potash content of the principal plants, natural and cultivated, in the tobacco sections have been compiled, and are given in the following table, together with the ratio of chlorin to the potash used by these plants, on the average.

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*Md. Expt. Station Bul. 26, and Article by author in Agricultural Science Vol. 8, p. 329.

## TABLE II.

*Showing the Relative Amounts of Chlorin and Potash Used by Plants Common in Tobacco Sections.*

| | Chlorin Cl. | Potash K. O. | Ratio of Chlorin to potash. |
|---|---|---|---|
| Woods: | | | |
| Chestnut*........................ | 0.9 | 13.0 | 1: 14.4 |
| Hickory,* ........................ | 0.3 | 18.9 | 1: 63.0 |
| Oak, ........................ | 0.2 | 10.0 | 1: 50.0 |
| Pine (Black),* ........................ | 0.7 | 10.4 | 1: 14.9 |
| Pine (Old Field),. ........................ | 0.6 | 2.5 | 1: 4.2 |
| Pine (Red),. ........................ | 4.0 | 5.2 | 1: 1.3 |
| Pine (White). ........................ | 0.2 | 1.53 | 1: 76.5 |
| Pine (Yellow),* ........................ | 0.8 | 13.0 | 1: 16.2 |
| Cultivated Plants: | | | |
| Corn (Fodder) ........................ | 1.4 | 36.3 | 1: 25.9 |
| (Grain), ........................ | 0.9 | 29.8 | 1: 33.1 |
| Oats (Straw),. ........................ | 4.4 | 26.4 | 1: 6.0 |
| (Grain), ........................ | 0.9 | 17.9 | 1: 19.9 |
| Rye (Straw), ........................ | 2.2 | 22.6 | 1: 10.3 |
| (Grain) ........................ | 0.5 | 32 1 | 1: 64.2 |
| Wheat (Straw), ........................ | 1.7 | 13 7 | 1: 8.0 |
| (Grain),. ........................ | 0.3 | 31.2 | 1:104.0 |
| Potatoes (Tuber), ........................ | 2.8 | 59.8 | 1: 21.4 |
| (Vine), ........................ | 4.6 | 14.5 | 1: 3.2 |
| Clover (Red), ........................ | 3.7 | 34.5 | 1: 9.3 |
| Timothy,. ........................ | 5.0 | 28.8 | 1: 5.8 |
| Broom Sedge (Andropogon Virginicus)† ........................ | 6.4 | 13.9 | 1: 2.2 |

*Analysis copied from Bul. No. 2, Ga. Exp. Sta.; other analysis taken from Prof. Emil Wolff's tables.

†Richardson's Analysis of Grasses of United States.

It is well known in Maryland that the pine lands (commonly a species of red pine) are the best lands for tobacco; the chestnut lands rank next, and oak and hickory lands are commonly regarded as poor tobacco soils. In some sections of the State, fields (termed old fields) are allowed to remain idle for some time, with an idea of reclaiming them for tobacco. The most prominent growth on these old fields at first is broom sedge grass (Andropogon virginicus), and if the field is allowed to run long enough, it comes up in pines, known as "old field pines." Now by turning to Table II, we find that there is a very great difference in the ratio of chlorin to potash taken out of the soil by these different plants. We also know that, in a given section, soils do not vary very greatly in their content of chlorin, consequently we see that the differences in amounts of chlorin left in the soil by these natural growths is very material, and enough to account for a difference in the quality of tobacco grown upon the different classes of soils.

An examination of the table also shows that the different cultivated crops take up very different proportions of potash and chlorin, and we can see how these crops would soon create a marked difference in the relative amount of these foods in the soil, and even this difference would be exaggerated when we consider that the amount of available potash would be used up while all the chlorids of the soil would be readily available.

The figures given in the table for the "old field pine" and for the broom sedge: show that these plants are valuable renovators of tobacco lands that produce tobacco of poor quality; and the practice of farmers of turning fields out and allowing them to grow up in sedge and pine has good scientific reasons underlying it.

## THE ROOT SYSTEM OF THE TOBACCO PLANT.

Roots are the water and food gatherers of plants. Roots are of two kinds;—the "tap root," the chief use of which is to sustain the plant in an upright position; and the "fibrous roots," which are engaged mainly in absorbing food from the soil. These roots are made up of cells through which the food for the plant is absorbed in solution. Solid matter cannot pass into the plant except it be in solution. The absorption of food is, however, not confined to taking up that which is naturally and readily formed in solution, but the roots produce an acid sap which has a dissolving action on the particles of soil containing plant-foods and thus renders them available.

The roots of tobacco all belong to the fibrous class, and will be seen by an examination of the pictures of the root washings made of plants at different stages of growth, as shown in Figs. 31 to 38.

These plants were grown on the Experiment Station farm in a clay soil which is moderately stiff, and consequently it was impossible to get them washed out without losing some of the roots and particularly the smaller and hairy portions. Hence these pictures represent less than the actual amounts, and, while they are not strictly accurate as to the relative positions of the root system, yet they are as nearly so as it is possible to represent them in a picture.

A careful study of the root system as shown in the engravings will clearly show that they spread steadily outward and downward, and enforce their own lesson regarding the depth of cultivation and of the vast importance of a mulch of loose soil, which will check, as much as possible, the loss of water from the surface of the ground, and hold it to be turned to use in maturing the crop.

## CULTIVATION.

The more nearly level and smooth the surface of the ground can be kept, the better. Thorough cultivation does not mean deep cultivation. Tobacco does best on a soil which is deep and loose, but the deepening and loosening of the soil should be done before the tobacco plants are set, and the shallower the cultivation which is given afterward, the more satisfactory will be the results. An examination of the pictures of the root system show that tobacco is in the main a shallow and surface feeder, so that whenever the soil is given a deep cultivation, which disturbs and breaks the roots, the plant is necessarily weakened by having its means for supplying moisture and nourishment decreased.

A constant supply of nourishment is as necessary to a growing plant as to a growing animal, and the cutting off of some of the roots of tobacco, as will be done by cultivating four to six inches deep, gives the plants a check from which they are liable never to recover.

Cultivation should begin immediately after the first rain that follows setting, and should be done as shallow as possible. Very good implements for this purpose are the chizel or harrow-toothed cultivator with pulverizing attachment, or the weeder cultivators. This kind of shallow cultivation should be done frequently and as long as possible, so as to have the land thoroughly mulched with a layer of dry earth.

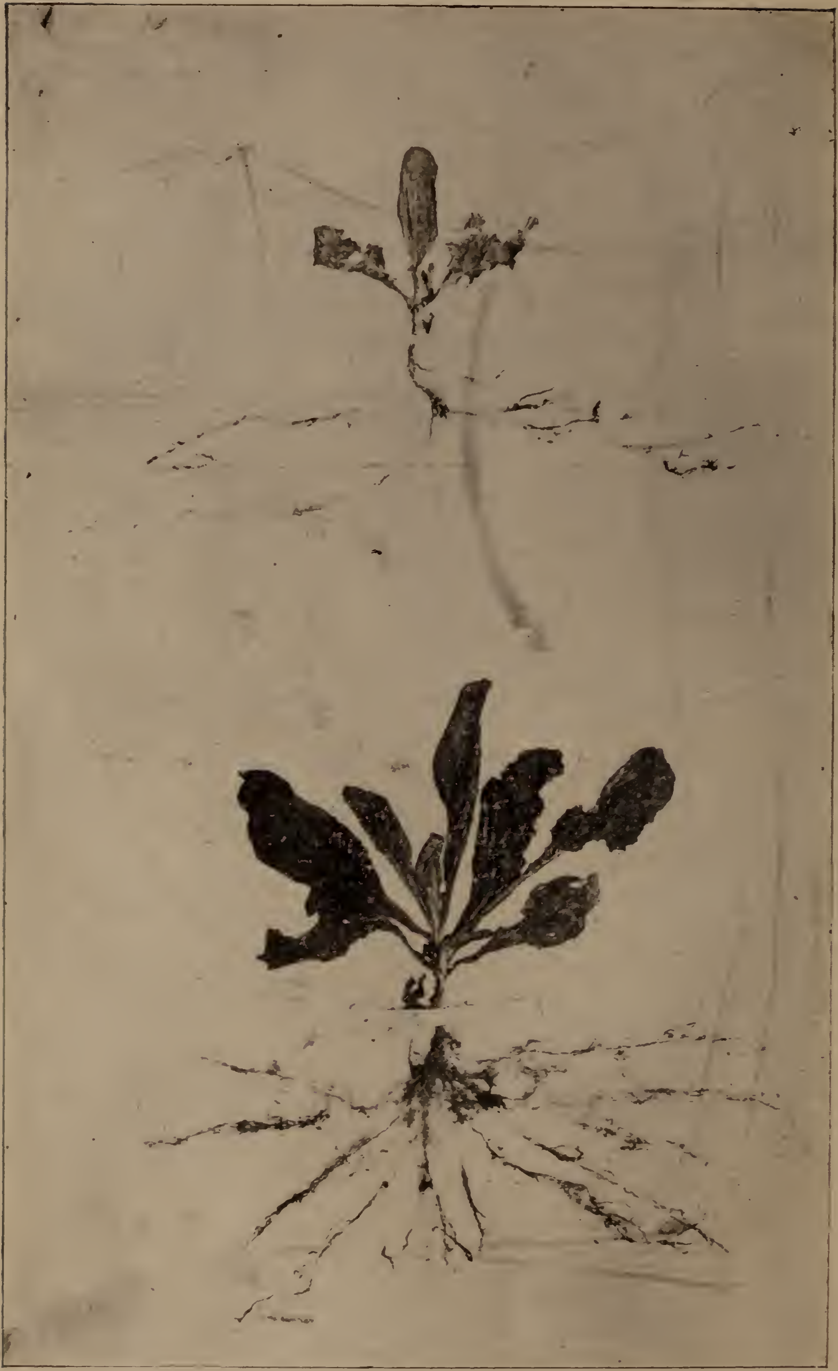

FIG. 32—Root System of Tobacco—Starting to Grow—First and Third Stages.

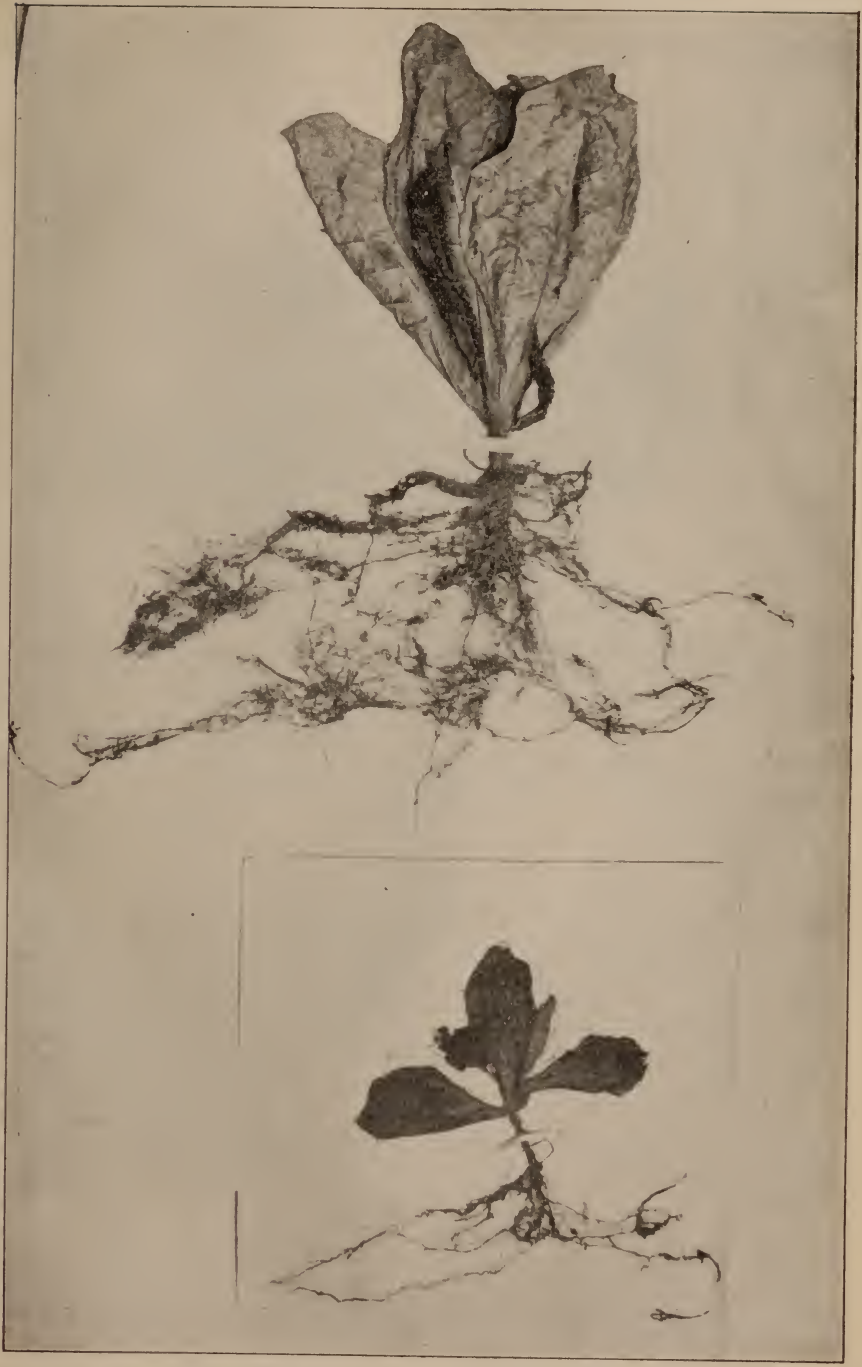

FIG. 33—Root System of Tobacco—Starting to Grow—Second and Fourth Stages of Growth.

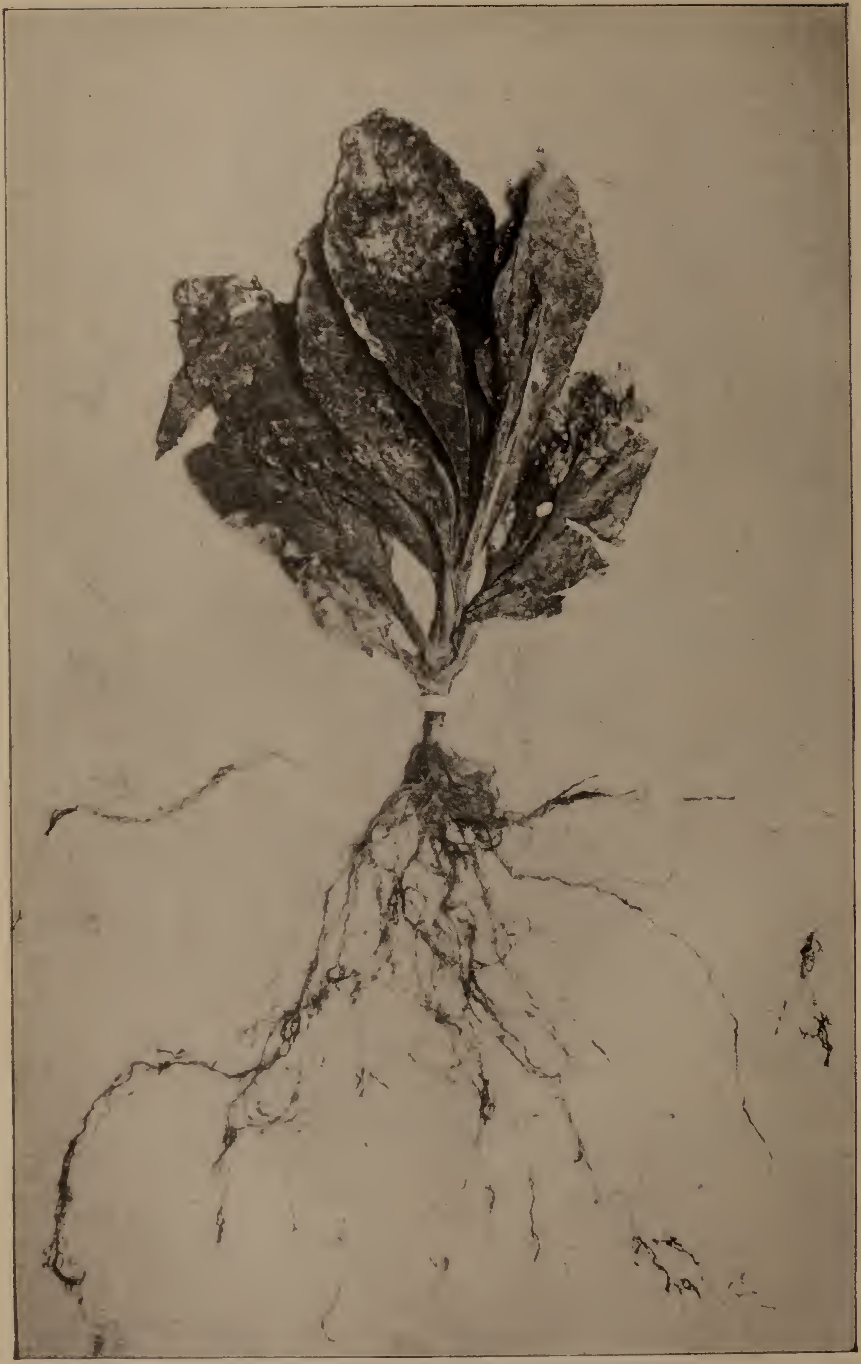

FIG. 34—Root System of Tobacco—Fifth Stage.

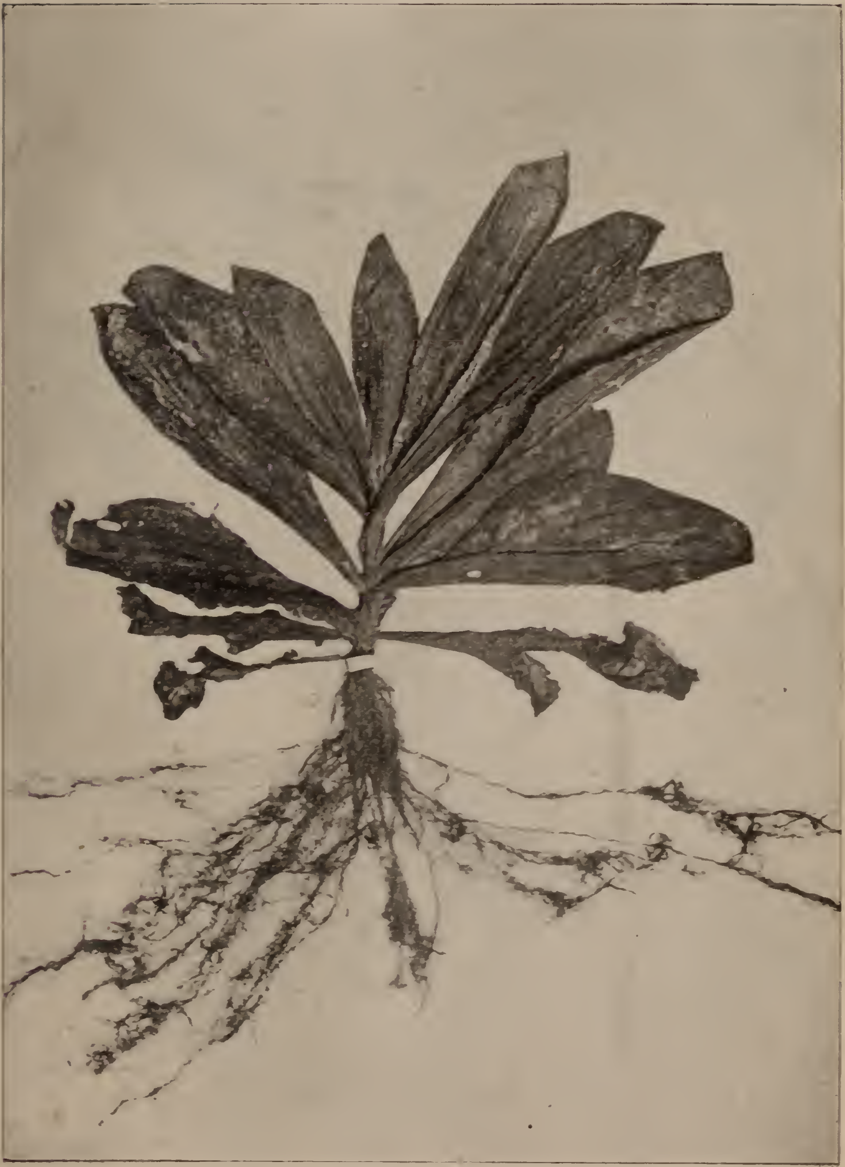

FIG. 35—Root System of Tobacco

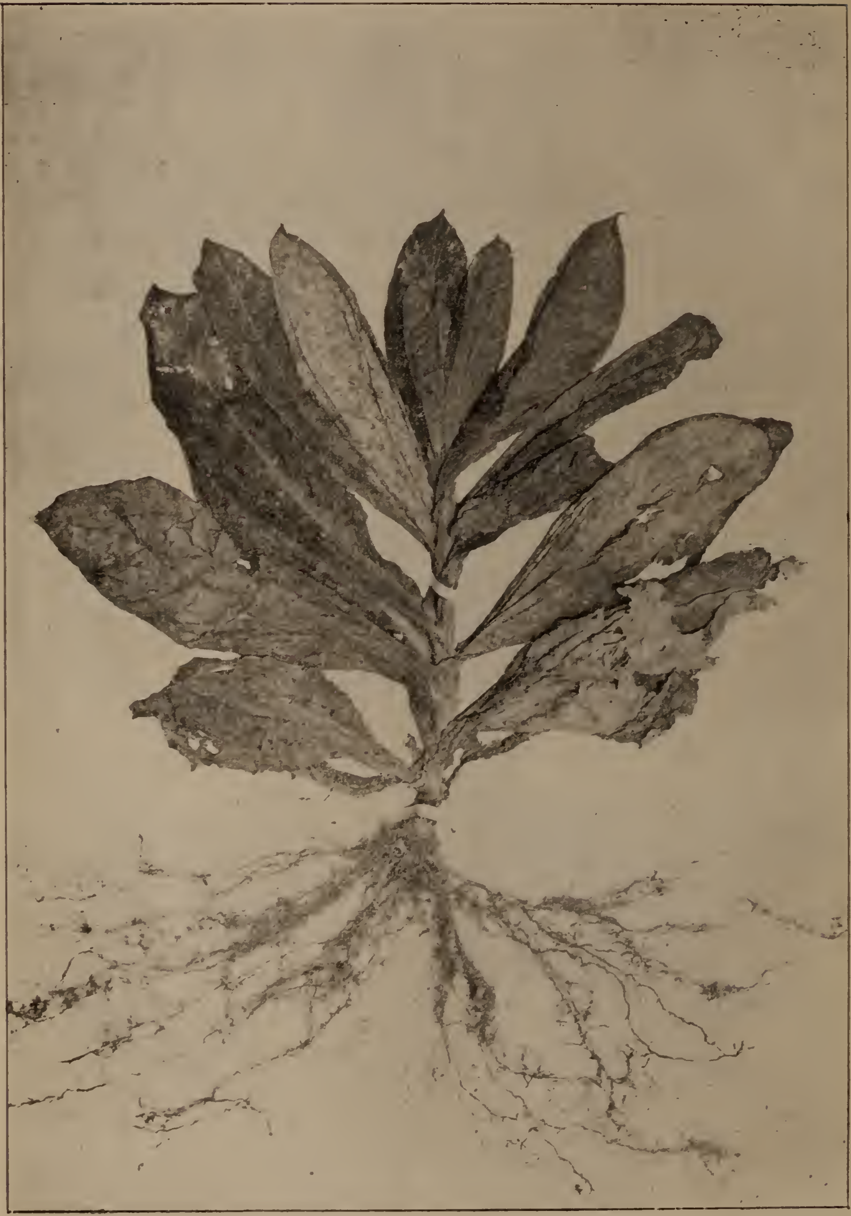

FIG. 36—Root System of Tobacco.

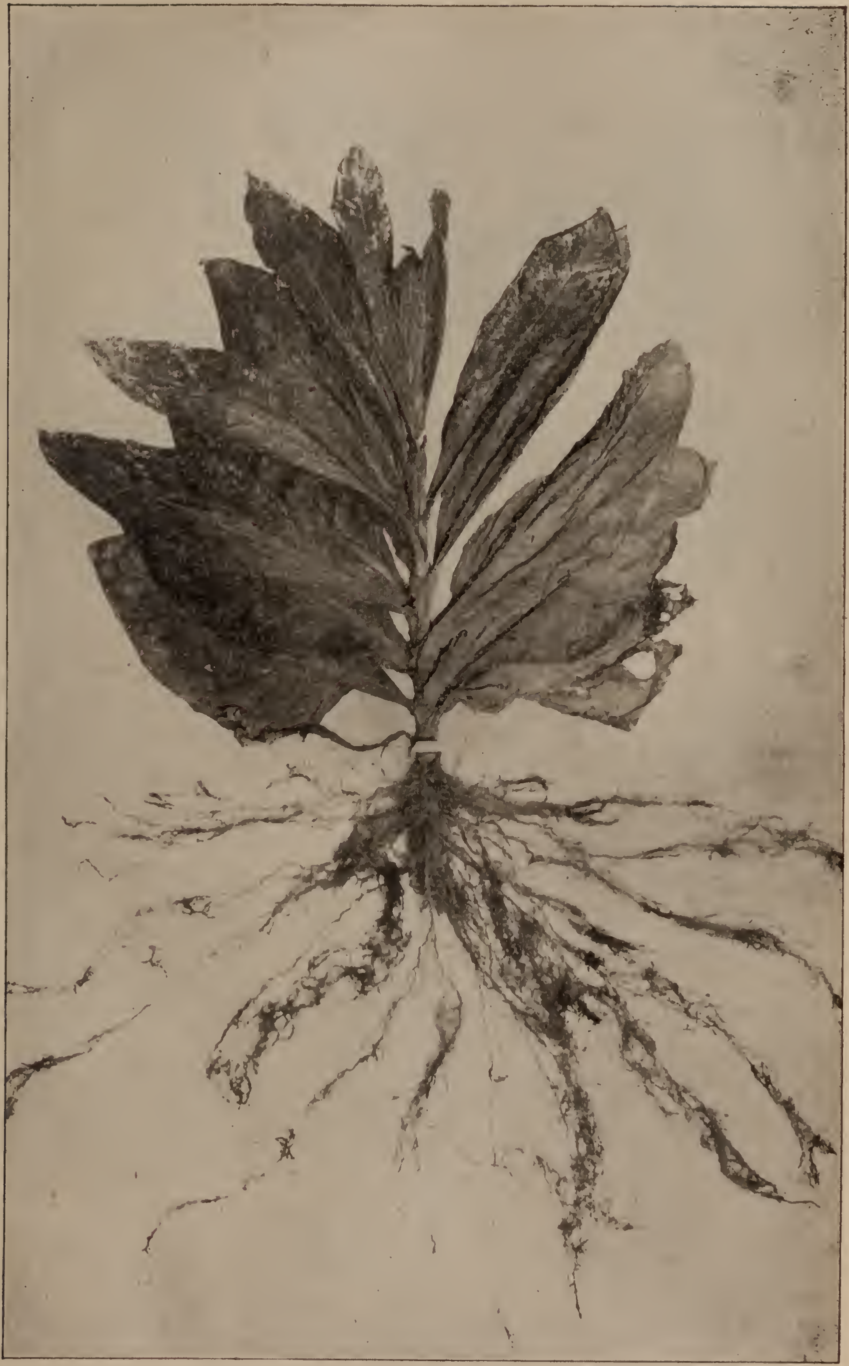

FIG. 37—Root System of Tobacco

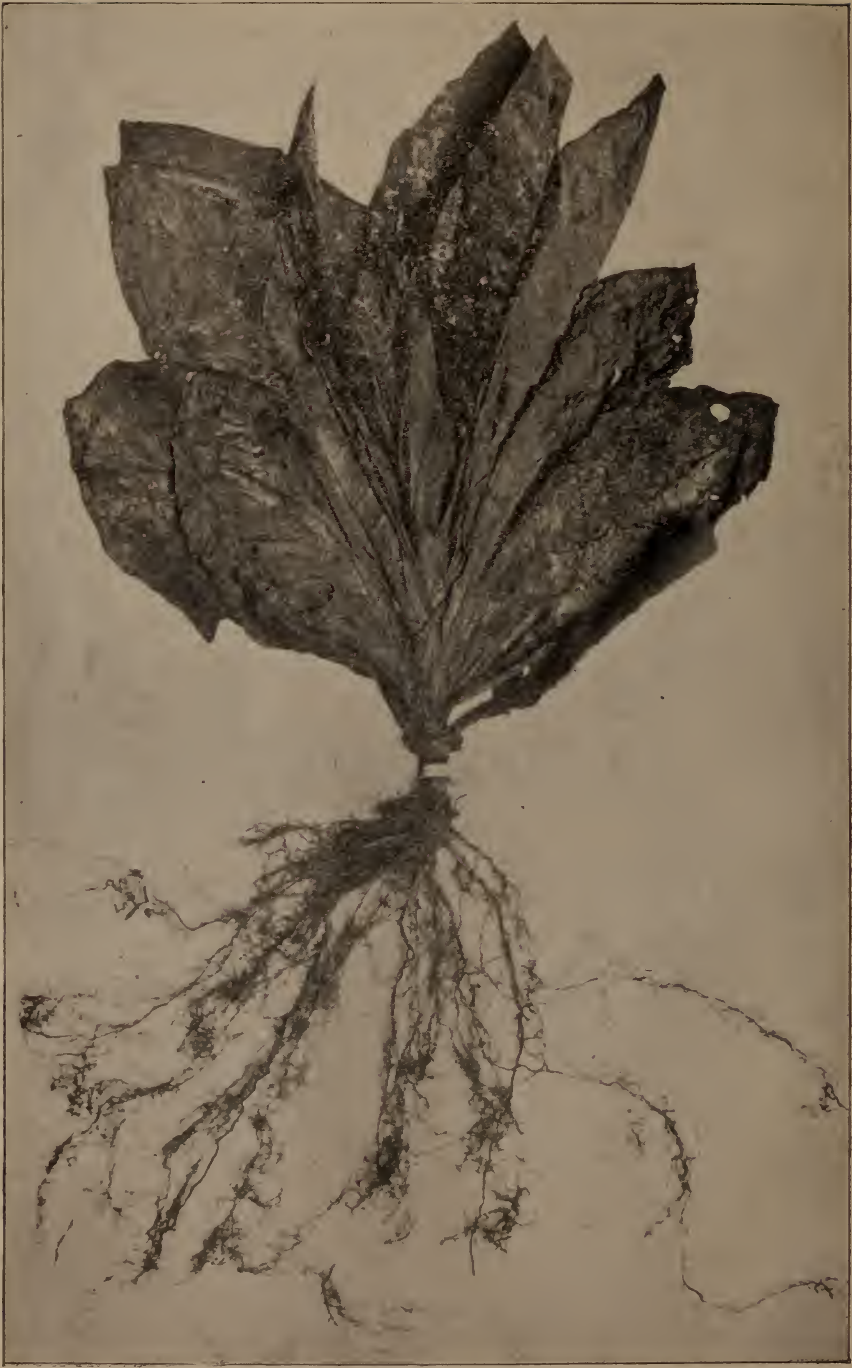

FIG. 38—Root System of Tobacco.

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